MURIEL LAKE BASIN HYDROLOGY STUDY – PHASE 2

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1. INTRODUCTION

1.1. PROJECT OVERVIEW

At the Muriel Lake Basin Management Society's (MLBMS) request, Solstice Environmental Management (Solstice) provided a scope of work for implementing Further study to evaluate identified locations of concern. This study is a follow-up to the 2020 Solstice Muriel Lake Hydrology study results and previous projects like the 2012 Millennium EMS Solutions Limited (Review of Muriel Lake Hydrology) and the 2015 Matrix Solutions Inc. (Surface Disturbance within Muriel Lake). Listed in the Project Work Scope section are the key objectives of the study.

1.2. PROJECT WORK SCOPE

The work scope of the study focused on the following:

- A desktop-based assessment of wetland and upland characteristics of the Locations of concern (see Table 1). This assessment included a LiDAR-based depression mapping to identify depressions and potential wetland presence or absence.
- Watershed mapping and stream profile analysis: Using the digital elevation model (D.E.M.) data, potential drainage areas of specific locations of concern as indicated by the Client were identified. The intent of the stream profile analysis is to identify potential areas of impoundments needing further investigation. This component shall require site verification, which can be completed in the spring or summer of 2022.
- Air photo acquisition and interpretation of select years: Solstice obtained historical air photos for 1949/50 and 1972 for each area of interest and compared these to recent imagery dating from 2013. These acquired historical aerial photographs were rectified using existing georeferenced base imagery to better understand the changes across the landscape. The review process shall assist with understanding the permanence of all wetland basins under investigation.
- Wetland Permitting and Crown Claimability Assessment: As a value-add to this project, Solstice provided guidance on permitting implications associated with the alterations of any wetlands, such as lowering culverts to facilitate better drainage. Solstice provided an assessment of the potential for wetlands or watercourses to be Crown claimable permitting implications under the Public Lands Act, in addition to permitting requirements under the Alberta Water Act and associated Wetland Policy. These implications will help aid in future decision-making as they will illustrate the cost-benefit of pursuing specific alterations to enhance water flows to Muriel Lake.

1.3. LOCATIONS OF CONCERN - DESCRIPTION

For this study, the Client provided to Solstice five locations of concern. Table 1 summarizes the quarter section location, location name, and description. Figure 1 presents the distribution of the locations to be investigated in the study.

TABLE 1. Locations of concern in Muriel Lake provided by Client.

Location #	MER	RGE	TWP	SEC	QTR	Description
1	4	5	59	19	NE	Slough on Franklins fields
1	4	5	59	19	NW	Slough on Franklins fields
1	4	5	59	19	SW	Slough on Franklins fields
2	4	4	60	8	SE	Access road to well site crossing ML-6 stream
2	4	4	60	8	NE	Access road to well site crossing ML-6

						stream
2	4	4	60	8	NW	Access road to well site crossing ML-6 stream
2	4	4	60	8	SW	Access road to well site crossing ML-6 stream
3	4	5	60	1	SE	Slough at Beaumieux
4	4	5	59	15	NW	Ponded water beside Township Road 593A
5	4	4	59	20	NW	“Holyoke” ponded water upstream of road crossing stream ML 3-1

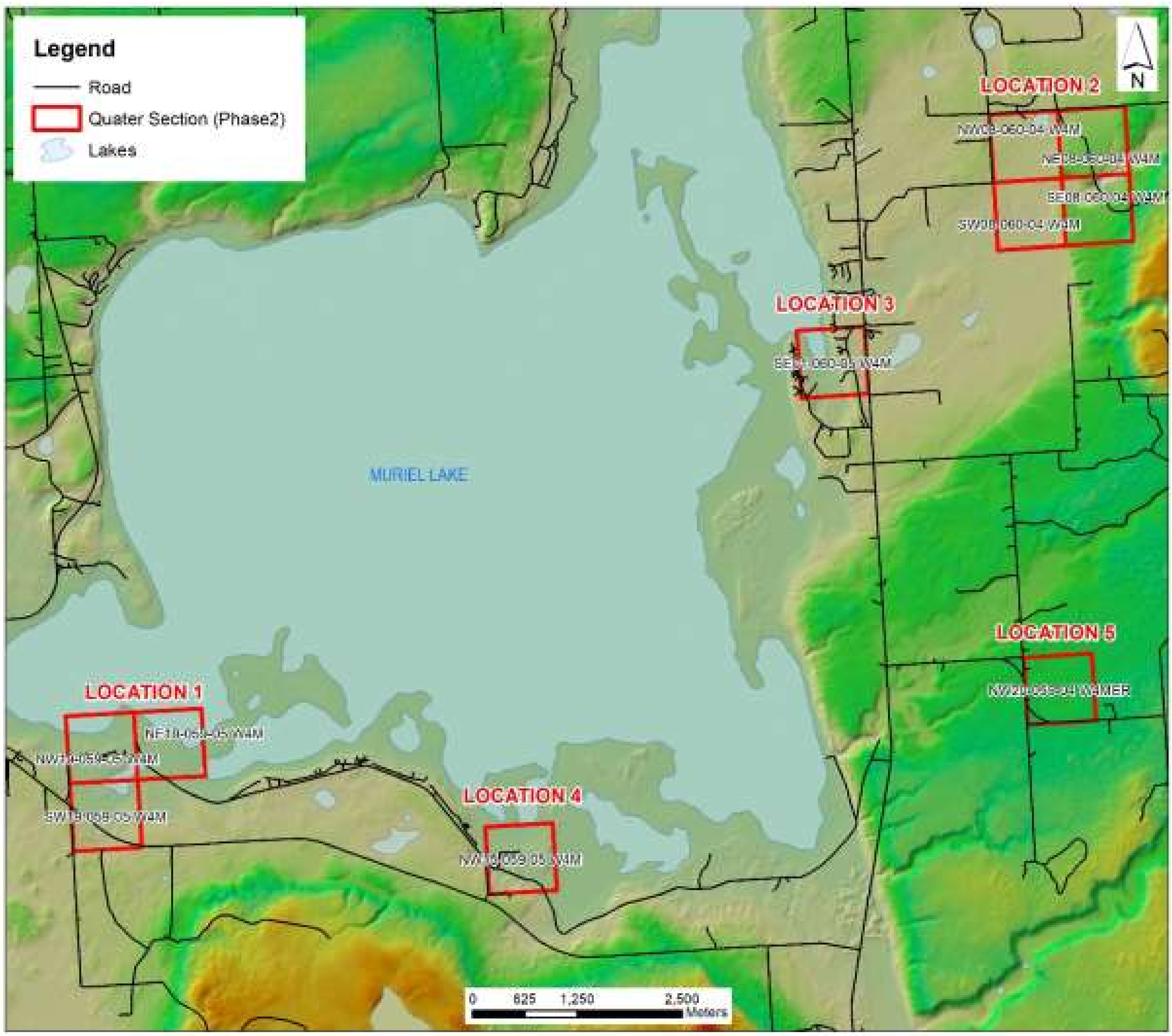


FIGURE 1. Distribution of locations of concern identified in the surface disturbance study

2. DESKTOP WETLAND ASSESSMENT RESULTS

2.1. WETLAND CLASSIFICATION METHODOLOGY

Solstice's desktop wetland maps accurately delineate and classify wetland and upland landcover classes. This service utilizes current imagery, providing up-to-date and accurate mapping of most wetland basins.

The Solstice mapping process classifies wetlands into five classes identified in the Alberta Wetland Classification System (ESRD 2015): bog, fen, swamp, marsh, and shallow open water. The classification process includes a combination of spectral information from Sentinel-2 multispectral imagery and topographic variables derived from bare earth Light Detection and Radar (LiDAR) data. The wetland mapping process complies with the Alberta Wetland Mapping Standards and Guidelines (AEP 2020).

A summary of the inventory of wetland classes and associated spatial extent, or total area, across the locations of concern are presented in table 2 below and in the attached figure (see Appendix A). This information is current as of the date the images were obtained (October 2020).

TABLE 2. Mapped Wetlands and Spatial Extent Summary

Area of Concern	Location	Wetland Class	Number of Wetlands	Spatial Extent (ha)	Spatial Extent (ac)
Location #1	NE-19-059-05 W4M	Marsh	1	1.09	2.70
	NE-19-059-05 W4M	Water	1	2.20	5.43
	NW-19-059-05 W4M	Marsh	1	4.38	10.83
	SW-19-059-05 W4M	Marsh	1	4.10	10.13
	SW-19-059-05 W4M	Swamp	1	3.13	7.73
Location #2	NE-08-060-04 W4M	Marsh	1	1.10	2.72
	NW-08-060-04 W4M	Marsh	20	13.51	33.39
	NW-08-060-04 W4M	Water	1	3.07	7.58
	SE-08-060-04 W4M	Marsh	2	4.65	11.49
	SW-08-060-04 W4M	Fen	2	34.57	85.42
	SW-08-060-04 W4M	Marsh	2	0.70	1.74
Location #3	SE-01-060-05 W4M	Marsh	1	4.32	10.69
Location #4	NW-15-059-05 W4M	Marsh	1	0.02	0.05
	NW-15-059-05 W4M	Swamp	4	4.92	12.15
	NW-15-059-05 W4M	Water	1	0.31	0.76
Location #5	NW-20-059-04 W4M	Marsh	15	2.64	6.51
	NW-20-059-04 W4M	Swamp	1	0.52	1.29
Total Wetland Area				**85.23**	**210.62**

3. WATERSHED MAPPING AND INHIBITED FLOW ANALYSIS

3.1. WATERSHED MAPPING APPROACH

The Watershed mapping process models the movement of water over the land surface. In this study, we model the movement of water over the land using a 15-meter LiDAR DEM raster dataset. Using the DEM raster as input, the process divides the terrain into separate watersheds and determines the steam network for each. Watersheds can also be divided into basins (i.e. subwatersheds) associated with particular branches of the stream network. The products generated from this process are the predicted streamlines and basin polygons (watershed and subwatershed). The predicted streamlines were used to calculate the stream profiles of selected locations of concern as requested by MLBMS.

The Watershed analysis highlights performed in this study are as follows:

- Compute vector flowpaths, watersheds, basins, and ridgelines from the LiDAR DEM raster
- Control drainage network density and basin sizes using flow accumulation thresholds for outlet, upstream limit, and branching points. This process involved recomputing and saving multiple versions of the flowpaths and basins using different criteria.
- Automatically fill spurious and small depressions in the DEM and set thresholds to leave larger/deeper depressions unfilled.
- Model internal drainage areas.
- Compute upstream catchment area and downstream flow path for specific locations by manually placing seed points in a view of the DEM or by loading them from a vector geodata layer.
- Save Watershed results.
- Compute hydrologic/geomorphic characteristics of the DEM cells: specific catchment area, compound topographic index, maximum upstream flow distance, and downstream flow distance.
- Compute hydrologic attributes of flowpaths: stream order, elevation drop, average slope, sinuosity ratio, upstream and downstream flow distances, and others.
- Created segmented flow path network using elevation or flow accumulation values.

3.2. QUANTIFYING WATER VOLUME FOR MURIEL LAKE SUB-CATCHMENTS

This section presents the results and approach used to calculate the volume of water per sub-catchments for the locations of concern.

3.2.1. Approach

In 2015, the Alberta Ministry of Environment and Sustainable Resource Development completed a hydrology study for Muriel Lake to understand the lake's water levels. The report presented statistical analysis on the lake levels reported at the weather station 06AC007 situated in Gurneyville.

The water balance study on the lake estimated the annual average run-off in the entire Muriel Lake basin as **22 mm per square meter**. By multiplying the unit area run-off times the spatial extent of the upstream area, an estimate of the water volume affected per sub-catchment can be calculated. This approach was developed in close consultation with MLBMS. Table 3 presents the water volume of each sub-catchment for the locations of concern investigated in this study.

Appendix B presents a base map of the mapped subwatershed (catchment areas) and predicted streamlines of the five locations of concern identified by the Client.

TABLE 3. Summary of the calculated water volume of each subcatchment in the study.

Area of Concern	Sub-catchment ID	Description	Subcatchment Area (ha.)	Volume (m^3)	Volume (decameters / years)
Location #1	L1-1	Subcatchment - downstream Township Road 593A	17.81	3917.58	3.92
	L1-2	Subcatchment - upstream Township Road 593A	70.67	15546.41	15.55
	L1-3	Subcatchment - upstream Highway 657	88.31	19428.41	19.43
Location #2	L2	Subcatchment Location 2	668.05	146971.10	146.97
Location #3	L3	Subcatchment Location 3	122.46	26940.23	26.94
Location #4	L4-1	Subcatchment - downstream Township Road 593A	21.47	4723.08	4.72
	L4-2	Subcatchment - upstream Township Road 593A	16.40	3607.30	3.61
	L4-3	Subcatchment - upstream Highway 657	10.54	2318.03	2.32
Location #5	L5-1	Subcatchment - upstream Township Road 593A	175.20	38543.93	38.54
	L5-2	Subcatchment - downstream Township Road 593A	199.49	43886.89	43.89

3.3. INHIBITED FLOW ANALYSIS

This component of the study identifies impoundment locations for the areas of concern provided by MLBMS at the start of the project. A longitudinal profile analysis of stream and creek channels was performed using standard GIS tools to determine the impounded locations. The approach adopted for this analysis entailed identifying the most likely path for water flow and generating the stream profiles. Based on the concerns of MLBMS, predicted stream profiles were generated for Locations #1, #3 and #4. Predicted stream profiles for Locations #2 and #5 were previously presented in the Phase 1 report as ML-6 and ML-3, respectively. Table 4 summarizes the profile analysis results for the four locations identified for streamline profile analysis.

TABLE 4. Summary of profile analysis results performed in the study.

Location #	Observations / Remarks
Location #1	The results show no significant obstruction to water flow direction for Location #1.
Location #3	*Potential impoundment locations along predicted streamline at Location #3* • Chainage 26 – 32 meters: A rise in elevation of approximately 1.74 meters between chainages 26 and 32 meters. This elevation rise was located at the edge of Highway 657. The coordinates are as follows: **525,789.61 mE, 6,000,905.97 mN, 572.32 m** elevation. • Chainage 376 – 400 meters: A depression of approximately 2.5 meters was observed at this location. This needs to be further investigated using field visits. The coordinates for chainage 376 meters are **525,490.93 mE, 6,000,926.20 mN, 570.19m** elevation. • Chainage 456 – 465 meters: A rise in elevation of approximately 1.82 meters between chainages 456 and 465 meters. The coordinates are as follows: **525,420.74 mE, 6,000,925.27 mN, 564.22** m elevation. A site validation for this location is recommended.
Location #4	*Predicted Streamline profile within Location #4 Sub-catchment:* • The stream profile results show no significant impoundment to the predicted streamline within the sub-catchment for Location #4.
Location #5	The streamline profile results show no significant obstruction to water flow direction for Location #5.

3.3.1. Location #4 – inhibited flow analysis result and field-verification

Although the profile analysis results for Location #4 indicated that the predicted streamline had no significant impoundment, ground-truthing investigations revealed a roadside ditch west of Location #4. The field locations visited were the east pond location (Longitude: -110.67633 degrees, Latitude: 54.10291 degrees) and a smaller pond – farther west (Longitude: -110.67722 degrees, Latitude: 54.1031 degrees) were visited (Figure 2). Figure 3 shows the east ponded water location at Location #4, which appeared to have a buried culvert that impounds water flow.

The elevation of the roadside ditch location (i.e. smaller pond – farther west) relative to the surrounding landscape was higher, resulting in an obstruction to water flow uphill to the east. Based on the field observations by MLBMS, it is suggested that deepening the ditch on the upstream (southern side of the road) be performed. To the north of the east pond location, it was observed that some clearing and deepening is necessary to aid water flow beyond the fenceline north of the site.

Based on the 2015 Matrix study, a culvert presence was field verified for the predicted streamline profile crossing Hwy 657.

FIGURE 2. Map showing the sites visited at Location #4

FIGURE 3. Field verification photograph showing the east ponded water site at Location #4 (Left) and a buried culvert that impounds water flow (Right).

4. HISTORICAL AIR PHOTO REVIEW OF WETLAND AND SURFACE WATER CHANGES

To better understand changes to the existing landscape over time, in particular wetlands, other water features and natural upland vegetation, a comprehensive review of historical air photos were completed for each location of interest identified by the Client. This information provides context for determining the potential permanence of wetland features. This is a factor in determining crown claimability, as crown-claimed wetlands are identified as permanent, naturally occurring bodies of water.

Historical aerial photographs dated 1949 and 1972 were compared to 2013 or 2017 high-resolution multispectral imagery to understand changes in surface water, wetland extent and connectivity to Muriel Lake over the three-time periods. We interpreted the results relative to pertinent precipitation data obtained during and preceding the air photos or satellite imagery dates, providing the relevant context of climatic conditions and variability. Solstice utilized available precipitation records (1955 to 2019) from weather stations around the study area (AAF, 2020). The historical trend analysis of the precipitation data for all locations of interest is reported in Section 4.1 of this report.

4.1. HISTORICAL PRECIPITATION DATA ANALYSIS

Solstice performed a historical analysis of precipitation levels to understand the observed trends of climate variability during the time frame of historical air photo review (1949 to 2017). The precipitation data was sourced using the Alberta Climate Information Service (ACIS) web-based interactive tool. A total of four Alberta township grids cover the locations of concern investigated in this study, including:

- T059R05W4 (Locations #1 and #4),
- T060R04W4 (Location #2),
- T060R05W4 (Location #3), and
- T059R04W4 (Location #5).

For Locations #1 and #4, the precipitation data for the three years analyzed corresponding to the air photo interpretation dates were 1955 (closest to 1949), 1972, and 2013. The yearly precipitation levels were 491.31 mm, 374.93mm, and 337.5 mm (Appendix C). The dry, wet, and normal years were determined relative to the average precipitation levels from 1955 to 2019. For these locations of concern, the average precipitation between 1955 and 2019 was 423.05 mm. With this average precipitation, 1955, 1972 and 2013 were considered wet, dry, and dry years.

Appendix D presents the historical precipitation data for the township grid T060R04W4 (Location #2) from 1955 to 2019. The yearly precipitation data considered for Location #2 were 499.12 mm (1955), 382.18 mm (1972), and 497.38 mm (2017), respectively. With an average yearly precipitation of 425.4 mm (1955 – 2019), the years evaluated for this location of concern were classed as wet, dry, and wet.

The historical precipitation data for Location #3 (Appendix E) revealed the readings for 1955, 1972, and 2013 (dates of the air photos reviewed) were 492.65 mm, 371.58 mm, and 347.59 mm, respectively. The average yearly precipitation for Location #3 was determined to be 427.19 mm. Hence, the years considered (i.e. 1955, 1972, and 2013) were classified as wet, dry, and dry relative to the average annual rainfall.

Finally, for Location #5, the average precipitation level from 1955 to 2019 was 418.93 mm, and the precipitation levels for 1955, 1972, and 2017 were 493.55 mm, 383.4 mm, and 497.33 mm, respectively (see Appendix F). Based on the average precipitation, 1955, 1972, and 2017 were considered wet, normal, and wet years.

4.2. LOCATION #1: SLOUGH OF FRANKLIN'S FIELD

A review of historical aerial photographs for Location #1 indicates that the wetland basin of interest has been present since 1949. No direct connectivity is apparent between the wetland basin of interest and Muriel Lake. However, the lake may have some groundwater influence on the wetland basin in wet years with high precipitation, as indicated in the 1972 photo (see Figure 4).

While flow from the culvert under the road towards the lake has been observed (Source: MLBMS), the vegetation cover indicates higher water availability in the predicted streamline. As such, the influence of the small water flow has not created visible connectivity from the waterbody to the lake.

By 2013, lake levels have significantly dropped, and the wetland basin of interest has also correspondingly shrunk. A summary of crucial landscape changes is presented in Table 5.

TABLE 5. Historical Air Photo Review - Location #1: Slough of Franklin's Field

Imagery Year	Description
1949-1950	Muriel Lake level appears high, with some apparent influence between the wetland basin of interest and the lake, visible in NE 19-59-5 W4M. This wetland basin may act as a lacustrine wetland in times of high-water levels with potential groundwater connectivity to Muriel Lake. Wetlands located on the western half of NW 19-59-5 W4M appear as faint signatures. The wetland basin of interest seems to receive some flows from a series of apparent swamp wetlands south of the basin within SW 19-59-5 W4M. These wetlands have no observable connection to the more permanent wetland basin of interest.
1972	The Wetland basin of interest is highly inundated. Lake level also appears very high. Wetland basins west of the wetland basin of interest are inundated and connected to the larger feature. Imagery glare prevents the reviewer from determining if there is direct connectivity to the lake. As noted in the 1949-1950 imagery, the wetland basin of interest appears to receive some flows from a series of wetlands south of the basin within SW 19-59-5 W4M.
2013	In 2013 the lake level receded by approximately 460 m, and a roadway is now visible along the northeast edge of the wetland basin of interest. The road demarks the edge of the wetland basin of interest and acts as a barrier to any overland water flow eastward. However, a significant decline in lake level has resulted in almost 300 m of "new shoreline" between the lake and the wetland basin of interest compared to historic conditions observed in 1949 and 1972. Any previous connectivity between the wetland basin of interest and the wetlands to the south was disrupted by Hwy 657 construction.

The results showed that for Location #1, the spatial extent of water-covered land was approximately 1.1, 9.1, and 1.1 hectares in 1949, 1972, and 2013 respectively. The surface water area of the slough experienced a drastic increase of roughly 8 hectares between 1949 and 1972 and declined to 1.1 hectares in 2013. Figure 4 shows the changes in the spatial extent of water-covered land in Location #1.

FIGURE 4. The spatial extent of water-covered land in Location 1 for 1949, 1979, and 2013

4.3. LOCATION #2: ACCESS ROAD TO WELL SITE CROSSING STREAM (ML6)

A review of historical aerial photographs for Location #2 indicates that while this watershed experienced the creation of a small water body by beaver dam impoundment between 1949 and 1972, the extent of impoundment was significantly expanded due to culvert blockage after the construction of an oilfield access road after 1972. The wetland feature is not present in the 1942 imagery. A water body of approximately 0.5 hectares was visible in 1972. The 2017 imagery shows an oilfield site and an access road that runs across the watershed. Also, the waterbody extending upstream from the road crossing encompassed the upstream 1972 waterbody. The pond size was estimated at 1.9 hectares in 2017. MLBMS informed Solstice about beaver blockage activity of the culverts discovered in 2013 and subsequently cleared in 2015. The culverts were again discovered to be blocked in 2019. In 2020 the road and culverts were washed out. The Orphan well Association is now responsible for the well sites in this location and has reduced the size of the road crossing structure and reestablished culvert flow in 2021. A summary of crucial landscape changes is presented in Table 6.

TABLE 6. Historical Air Photo Review - Location #2 - Access Road to Well Site Crossing Stream (ML6)

Imagery Year	Description
1949-1950	The wetland basin near the northeast corner of NW 08-60-4 W4M appears dry but contains a visible wetland signature. A yard site is visible near the southwest corner of this wetland. There is no indication of connectiveness between this wetland basin and the wetland basin of interest that borders the oil and gas access road. A large clearing is visible within NE 08-60-4 W4M. However, the wetland basin of interest was not visible in 1949-1950. A watercourse, which does not appear channelized, is visible north of the wetland basin of interest. The outlet of the basin of interest is also not visible in this imagery.
1972	The wetland near the northeast corner of NW 08-60-4 W4M appears inundated. An indication of an outlet on the south end of this wetland is evident. The outlet seems to dissipate as it heads south. The wetland basin of interest (south of the large clearing within NE 08-60-4 W4M) is inundated and appears to have been formed as a result of beaver dam activity. The watercourse that passes through the basin of interest appears slightly more channelized near the wetland outlet. No roads or alterations impacting wetlands or watercourses are evident in this imagery.
2017	The wetland near the northeast corner of NW 08-60-4 W4M appears highly inundated. The outlet first noted in the 1972 imagery is evident in 2013. The outlet seems to consist of a smaller intermittent vegetated channel, which extends south to SW-08-60-4 W4M. The wetland basin of interest is highly inundated within SE 08-60-4 W4M. An oil and gas access road is present and extends south near the middle of SE 08-60-4 W4M and appears located along with the historic beaver dam feature evident in the 1972 photo. This access road seems to have resulted in further impoundment of water based on the 2013 imagery. In addition, two crossings, which may be for ATV access, are visible west of the access road. The outlet watercourse of the wetland basin of interest appears more channelized on the downstream end. Based on ponded water presence east of these crossings, it seems as if impoundment of the watercourse may also be occurring at these locations.

The review of the historical air photos (1949 and 1972) and the recent high-resolution World View imagery (2017) revealed that the surface water upstream of the crossing (chainage 2450m along ML6) was 0.5 hectares in 1972 and 1.9 hectares in 2017 (a change of approximately 1.4 hectares). In 1949, there was no surface water activity upstream of ML6 at chainage 2,450 meters (see Figure 5).

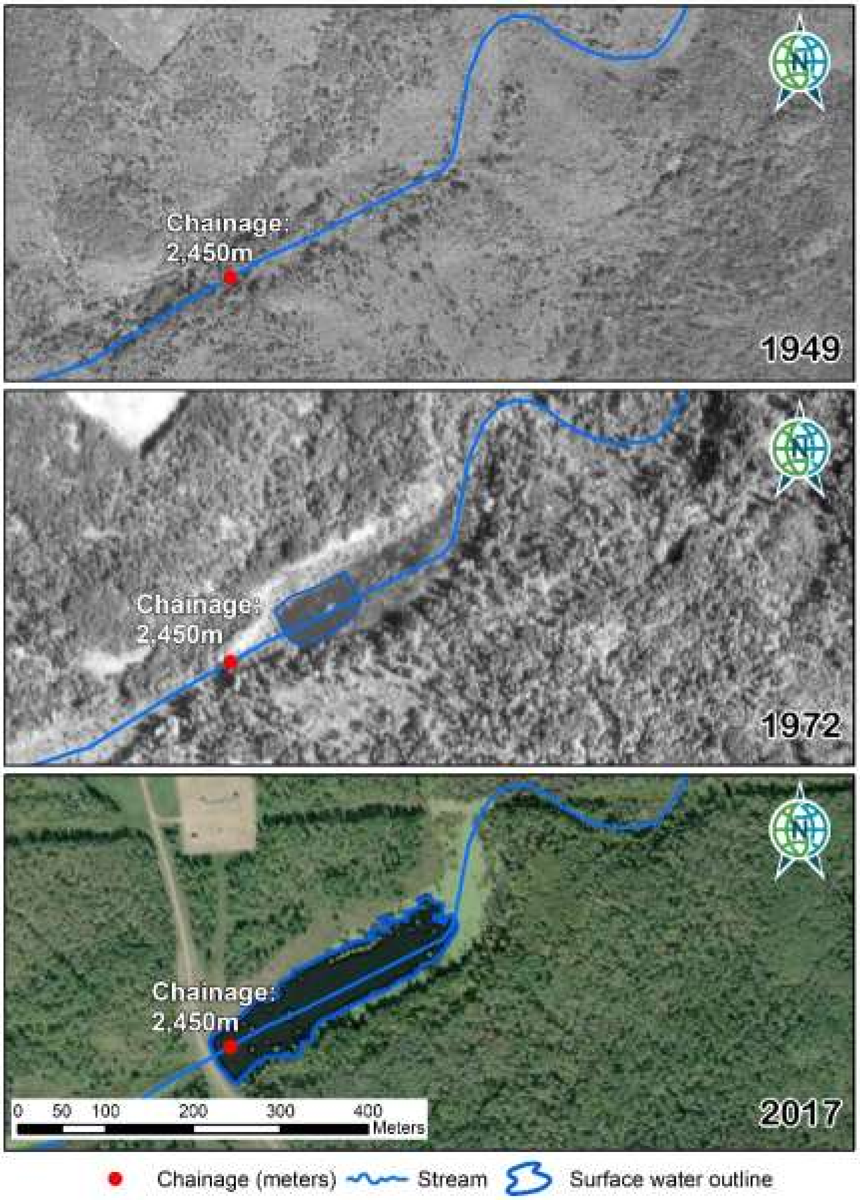


FIGURE 5. The spatial extent of water-covered land in Location #2, upstream of chainage 2450 meters on ML6, for 1949, 1972, and 2017.

4.4. LOCATION #3: SLOUGH AT BEAUMIEUX

A review of historical aerial photographs for Location #3 indicates that the wetland basin of interest has been present since 1949. Direct connectivity is apparent between the wetland basin of interest and Muriel Lake through an outflow watercourse channel that flows west from the wetland basin of interest into the lake. In 1972, the wetland basin of interest was clearly inundated and contained open water. By 2013, the entire wetland basin was fully inundated, and the wetland features to the west of the road included patches of open water. A summary of landscape changes is presented in Table 7.

TABLE 7. Historical Air Photo Review - Location #3 - Slough at Beaumieux

Imagery Year	Description
1949-1950	Lakeshore development is minimal. The roadway (now Lemieux Drive) runs north to south near the western extent of the large wetland basin of interest. A small, cropped section of land adjacent to Muriel Lake appears to be under agricultural production. Just south of this agricultural development, a small channel feature seems to be the outlet for the wetland basin within SW 06-60-4 W4M. The wetland basin, which primarily resides within SW 06-60-4 W4M, appears mostly dry and vegetated. As a result, no evidence of flow is visible.
1972	By 1972, Hwy 657 is now visible near the western edge of the wetland within SW 06-60-4 W4M. A small access road towards a beach on a bay of Muriel Lake is now visible. This access road is located south of the suspected outlet channel to Muriel Lake. The wetland within SW 06-60-4 W4M appears to contain some patches of open water.
2013	By 2013, lakeshore development along the shoreline of Muriel Lake has considerably altered the landscape. Multiple access roads and residences are now visible. The same outlet to the lake appears to have been retained. However, the presence of various access roads may be impacting water flows westward towards Muriel Lake.

Over the period investigated (1946, 1972, and 2013), Location #4 experienced increased water impoundment. The interpretation of the historical air photos and high-resolution imagery revealed that the surface area of the waterbody east of Hwy 657 was 6.4 hectares (1949), 9.4 hectares (1972) and 11.6 hectares (2013), respectively (Figure 6). Post-construction of Hwy 657 in 1972, the slough to the west of the highway experienced some fragmentation from its initial form indicated in Figure 6.

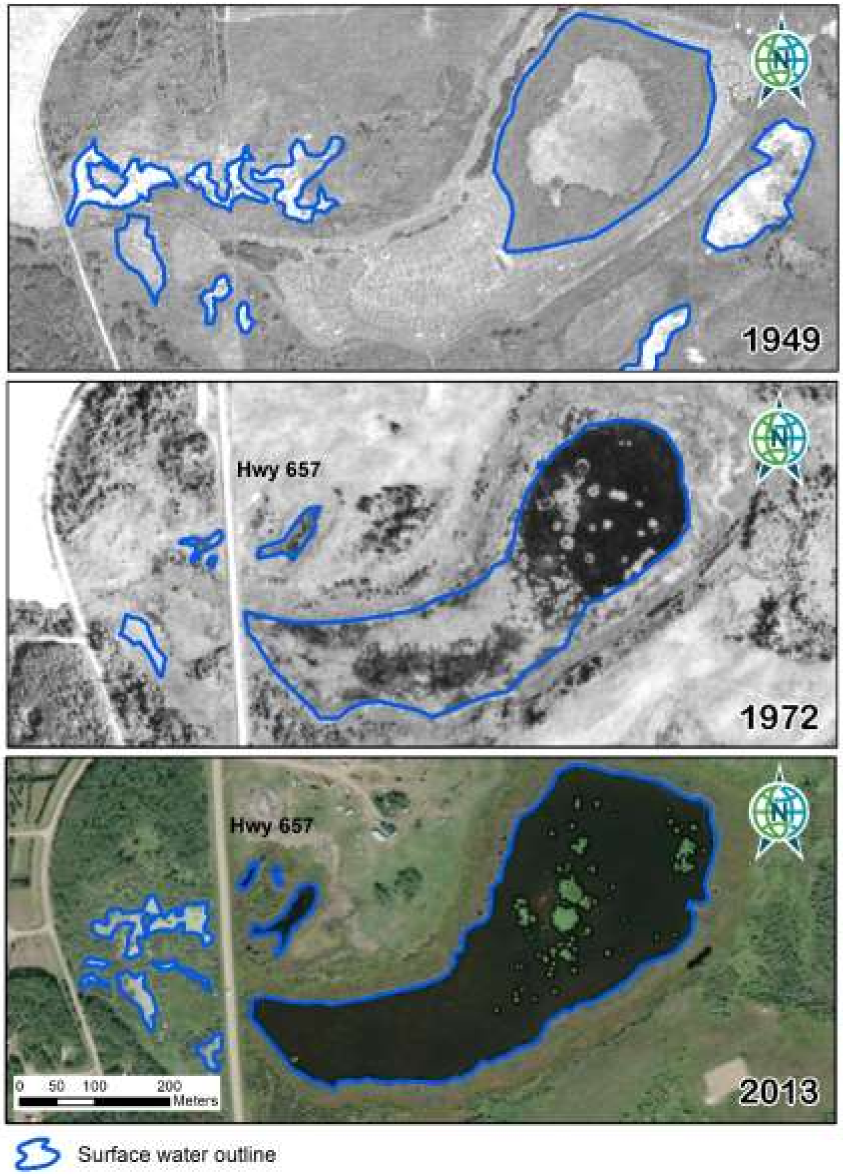


FIGURE 6. Changes in the spatial extent of the slough at Beaumieux for 1946, 1972, and 2013

4.5. LOCATION #4: PONDED WATER BESIDE TOWNSHIP ROAD 593A

A review of historical aerial photographs for Location #4 indicates that the various wetland basins have been present in the area of interest since 1949. These are all swamp wetlands that contain no surface water. While no direct connectivity is apparent between these wetland basins of interest and Muriel Lake, there may be some groundwater influence from the lake on the northernmost swamp wetland basin feature in wet years with high precipitation, as indicated in the 1972 photo. However, by 2013, lake levels had significantly dropped, and these wetland basins appear to be more disconnected from the lake. A summary of crucial landscape changes is presented in Table 8.

TABLE 8. Historical Air Photo Review - Location #4 - Ponded Water Beside Township Road 593a

Imagery Year	Description
1949-1950	From the air photo, some minimal disturbance is visible within the quarter section. It appears that a series of wetlands exists near the middle of the quarter section. No noticeable outlet is present.
1972	At this date, a road (Township 593A) is constructed through the quarter section. Swamp wetlands south of 593A are visible in the 1972 imagery. Inundation is limited, but standing water potential is difficult to infer with wetlands of this classification (swamp).
2013	By 2013 the lake level has dropped substantially. No outlet to the wetlands south of Township Road 593A is evident in earlier aerial imagery. There appear to be two isolated swamp basins located south of the roadway.

4.6. LOCATION #5: "HOLYOKE" PONDED WATER UPSTREAM OF ROAD CROSSING STREAM ML 3-1

A review of historical aerial photographs for Location #5 indicates that the ponded water is present at various locations within an existing watercourse channel that has persisted since 1949. In both the 1949 and 1972 photos, the watercourse is visible as a distinct channel surrounded by tree stands, though no ponded water is visible. By 2017, some ponded water was visible to the east of Range Road 45, indicating water impoundment caused by the road. Most areas along the watercourse were indistinguishable from the surrounding landscape were dry and vegetated. Table 9 summarizes the landscape changes for Location #5.

TABLE 9. Historical Air Photo Review - Location #5 - Holyoke" Ponded Water Upstream of Road Crossing Stream ML 3-1

Imagery Year	Description
1949-1950	No ponded water is visible within the imagery. A trail "roadway" runs north to south. A watercourse is visible and runs southwest-northeast across the upper half of NW 20-59-4 W4M. Much of the quarter section remains treed, except the central and western portions.
1972	By 1972 the roads in the area have been further developed. A yard site is visible within the northwest corner of NW 20-59-4 W4M. Much of the quarter section remains treed, including the watercourse previously identified. No ponded water is visible.
2017	By 2017 the northern half of the quarter section had been cleared. The watercourse appears indistinguishable in certain areas along its previous channel. Ponded water is visible to the east of Range Road 45. Trees have also been cleared west of Range Road 45 within the watercourse channel. West of the roadway and watercourse appears to be dry and vegetated.

For Location #5, the identified ponded water upstream of the road crossing at chainage 710 meters on the Muriel lake (ML) 3-1 present in 2017 was none existent in 1949 and 1972, respectively (see Figure 7). For this location of concern, the ponded water was a recent development based on historical records as shown in the aerial photographs (Figure 7). Hence, there was no change in the extent of water-covered land in this location of interest. Appendix G presents the historical air photo maps generated in the study.

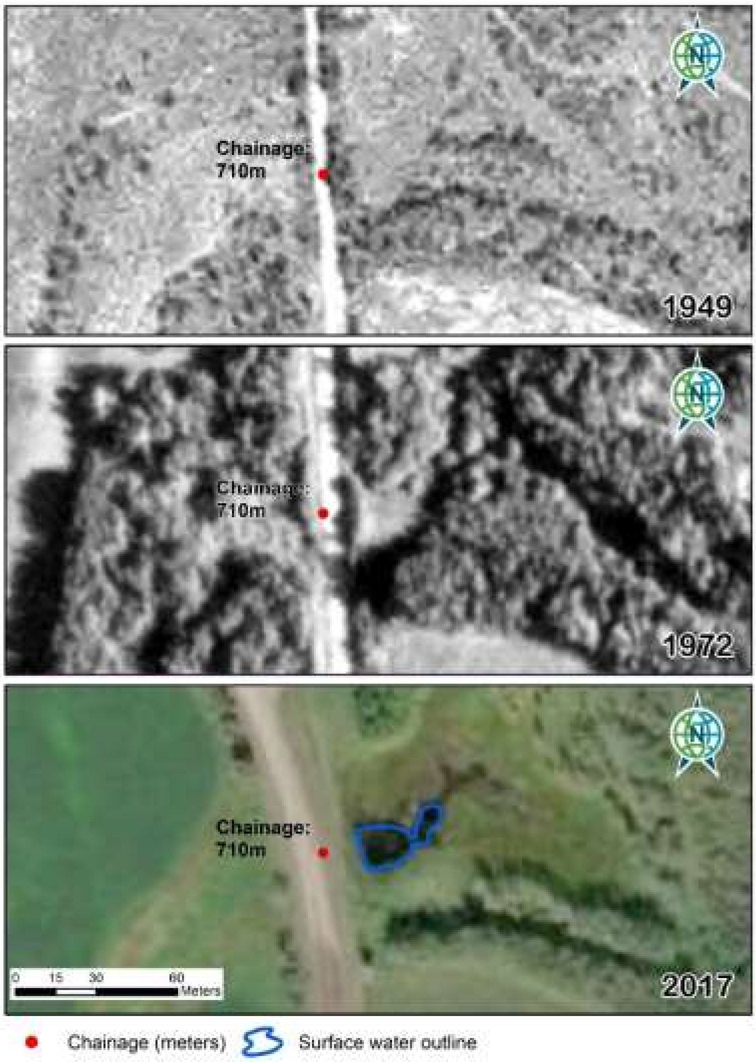


FIGURE 7. Historical air photographs (1946 and 1972) and recent high-resolution satellite imagery (2017) showing the "Holyoke" ponded water (Location #5).

5. WETLAND PERMITTING IMPLICATIONS

As a value add component to this project, Solstice has provided some general guidance on permitting implications associated with the alterations of any wetlands that may arise from installing the new culverts or lowering existing culverts to improve water flow in Muriel Lake. This information will help in future decision-making as it can assess the cost-benefit of pursuing specific alterations to enhance water flows to Muriel Lake. An assessment of potential permitting requirements for each location is presented in Table 10.

Under the Alberta Wetland Policy, any impacts to wetlands, such as draining, infilling, or other modifications, will require that a provincial *Water Act* approval application, along with a Wetland Assessment and Impact Report, including wetland mitigation and replacement plan, be completed and filed with Alberta Environment and Parks. In this case, any proposed alterations to existing drainage patterns that could lead to changes in the wetland area will require wetland approvals and potentially wetland replacement if the wetland area is lost. Except for Location #5, all locations are considered wetlands and require some form of *Water Act* approval. While no wetlands were noted at Location #5, this feature is a defined watercourse that would need a Code of Practice (COP) for Watercourse Crossings Notification for any culvert installation/modification/replacement activities.

Additionally, under the *Public Lands Act*, the province owns the bed and shore of any naturally occurring permanent wetlands, lakes, and rivers, as well as any stream where there is a defined bed and banks.

Any activities on public land or within a crown-claimed water body, including wetland features and watercourses, will require a Public Lands Disposition or Approval. To determine if any wetlands of interest would be considered crown-claimable, wetland permanence was assessed using the Guide for Assessing Permanence of Wetland Basins (AEP 2014). Based on this assessment, wetland features at two locations (Location #1 and #3) have the potential to be considered crown-claimable and would be subject to the *Public Lands Act.* In addition, the watercourses that occur at Locations #2 and #5 may also be regarded as crown-claimable, as they appear to have a defined bed and banks.

TABLE 10. Summary of Potential Permitting Requirements

Location #	Assessment of Wetland Permanence	Potential Crown-Claimabilty (Wetlands)	Potential Crown-Claimabilty (Watercourses)	Potential *Water Act*/Wetland Permitting
Location #1: Slough of Franklin's Field	Naturally occurring, semi-permanent to permanent marsh wetland feature	Yes	No	Yes, Water Act Approval required for any wetland disturbance or alteration
Location #2 - Access Road to Well Site Crossing Stream (MI6)	Semi-permanent to permanent wetland feature that has formed as a result of beaver dam impoundment	No, wetland feature is due to beaver impoundment of water	Yes, the watercourse appears to have a defined bed and banks and thus may be Crown Claimable	Yes, COP Notification or *Water Act* Approval may be required for any activities impacting a watercourse
Location #3 - Slough at Beaumieux	Naturally occurring,semi-permanent marsh wetland feature	Yes	No	Yes, *Water Act* Approval required for any wetland disturbance or alteration
Location #4 - Ponded Water Beside Township Road 593a	Swamp wetlands	No, as wetland features are swamps with no defined bed and banks	No	Yes, *Water Act* Approval required for any wetland disturbance or alteration

Location #	Assessment of Wetland Permanence	Potential Crown-Claimabilty (Wetlands)	Potential Crown-Claimabilty (Watercourses)	Potential *Water Act*/Wetland Permitting
Location #5 - Holyoke" Ponded Water Upstream of Road Crossing Stream MI 3-1	No naturally occurring wetlands are present	No	Yes, the watercourse appears to have a defined bed and banks and thus may be Crown Claimable	Yes, COP Notification or *Water Act* Approval may be required for any activities impacting a watercourse

6. CONCLUSION

In this study, Solstice has addressed the work scope listed in Section 1.2 of this report. A desktop-wetland assessment of the Locations of concern was provided to MLBMS. The results of this wetland mapping complemented the Wetland Permitting and Crown Claimability assessment. Solstice provided an evaluation of the potential for wetlands or watercourses to be Crown claimable permitting implications under the Public Lands Act, in addition to permitting requirements under the Alberta Water Act and associated Wetland Policy. The study's results present a table summarizing the potential permitting requirements (see Table 10). To better understand changes in the landscape for the locations of concern, a comprehensive change detection analysis was performed using historical air photos and available high-resolution satellite images.

Other work scopes included a watershed mapping and stream profile analysis of the Locations of concern and an air photo interpretation of selected years. A repository of map products was prepared and used to better understand the changes across the locations of concern identified by MLBMS. This review process assisted with understanding the permanence of existing wetland basins under investigation. The changes in surface water bodies across the study sites were discussed, and critical observations are presented in Section 4 of this report. The stream profile analysis of selected locations identified the presence or absence of potential areas of impoundments needing further investigation. The study's findings presented a list of possible sites requiring further investigation (see Table 4).

The work performed identified the following concerns regarding surface water flow to Muriel Lake:

1. Location #1: No concerns were identified. The extent of water-covered land appeared not to have increased significantly less than in 1972 when the lake was at its highest level. MLBMS should confirm the culvert at highway 657, 2 locations.
2. Location #2: Beaver activity and blockage of culverts under an oilfield access road created a large water body at this location. After the washout of the road in 2020, the crossing has been reconstructed, and the anthropogenic impoundment has been addressed. Beaver activity is expected to continue in this area. Continued monitoring of beaver-related activities was recommended for this location, but no action has been taken at this time.
3. Location #3: Inhibited flow analysis identified possible chain blockage between Lemieux drive and the lake in the forested area. A field investigation is recommended for this location.
4. Location #4: Repair to a buried culvert is recommended, and ditch grading is required for this location.
5. Location #5: No significant concerns were identified for this location.

7. REFERENCES

AEP. 2014. "Guide for Assessing Permanence of Wetland Basins." In, edited by Land Policy Branch, 28. Alberta Environment and Parks

AEP. 2020. "Alberta Wetland Mapping Standards and Guidelines: Mapping Wetlands at an Inventory Scale V1.0." In, edited by Alberta Environment and Parks. Edmonton, Canada: Government of Alberta

ESRD. 2015. "Alberta Wetland Classification System." In. Edmonton, AB: Alberta Environment and Sustainable Resource Development

APPENDIX A. SOLSTICE WETLAND MAPS

LEGEND

- Contour (1m interval)
- Predicted Drainage Path
- Project Area
- Quater Section Boundary
- Wetland Extent

Wetland Class

- Fen
- Marsh
- Swamp
- Water

SOURCES:
HYDROLOGY DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE – ALBERTA.
IMAGERY FROM ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY. IMAGERY DATE: 2013

0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

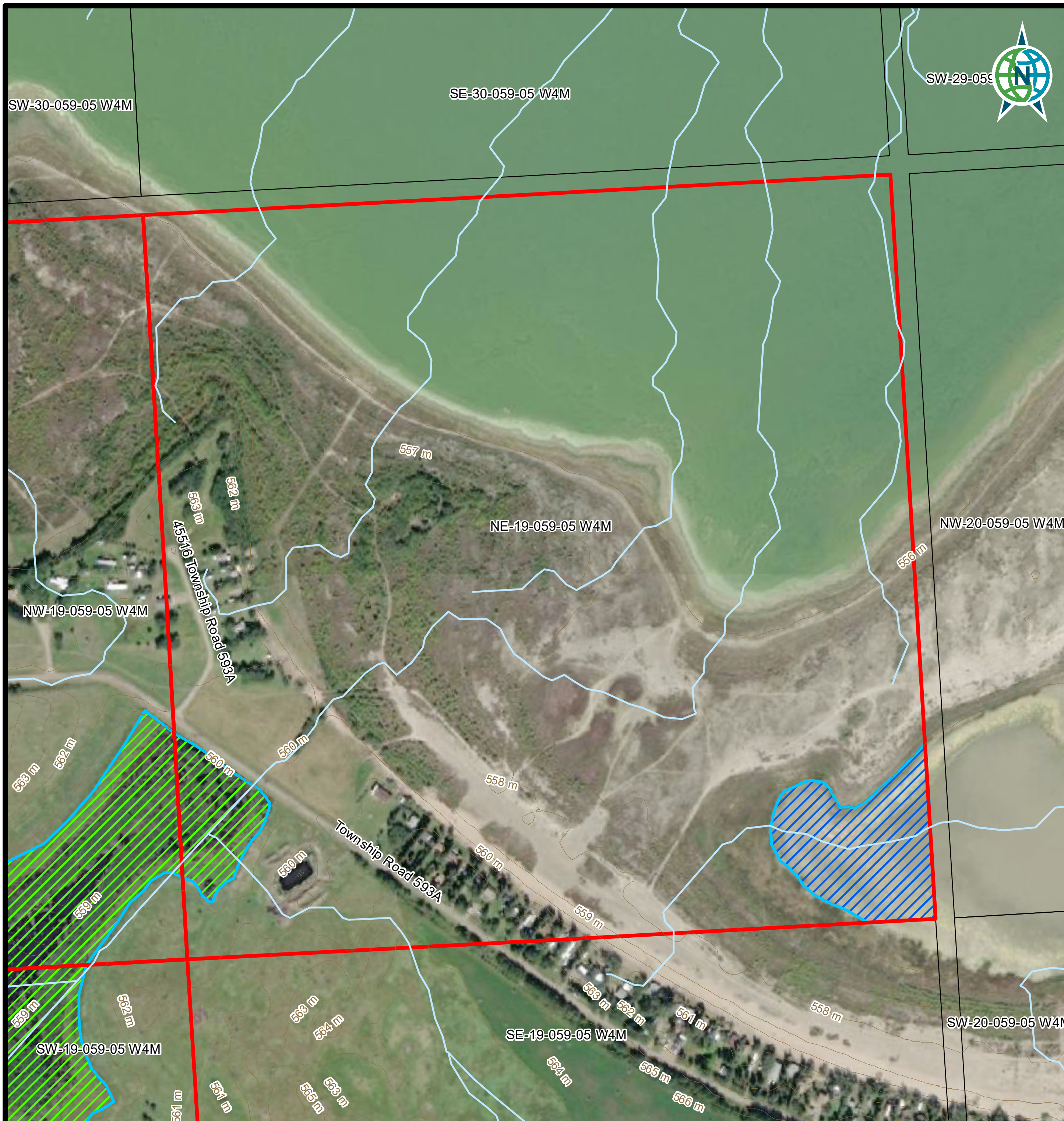
DESKTOP WETLAND ASSESSMENT FOR NW-19-059-05 W4M (LOCATION #1)

DATE:	PROJECTION:	DATUM:
OCTOBER 19, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:6,000

FIGURE A01



LEGEND

- Contour (1m interval)
- Predicted Drainage Path
- Project Area
- Quater Section Boundary
- Wetland Extent

Wetland Class

- Fen
- Marsh
- Swamp
- Water

SOURCES:
HYDROLOGY DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE – ALBERTA.
IMAGERY FROM ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY. IMAGERY DATE: 2013

0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

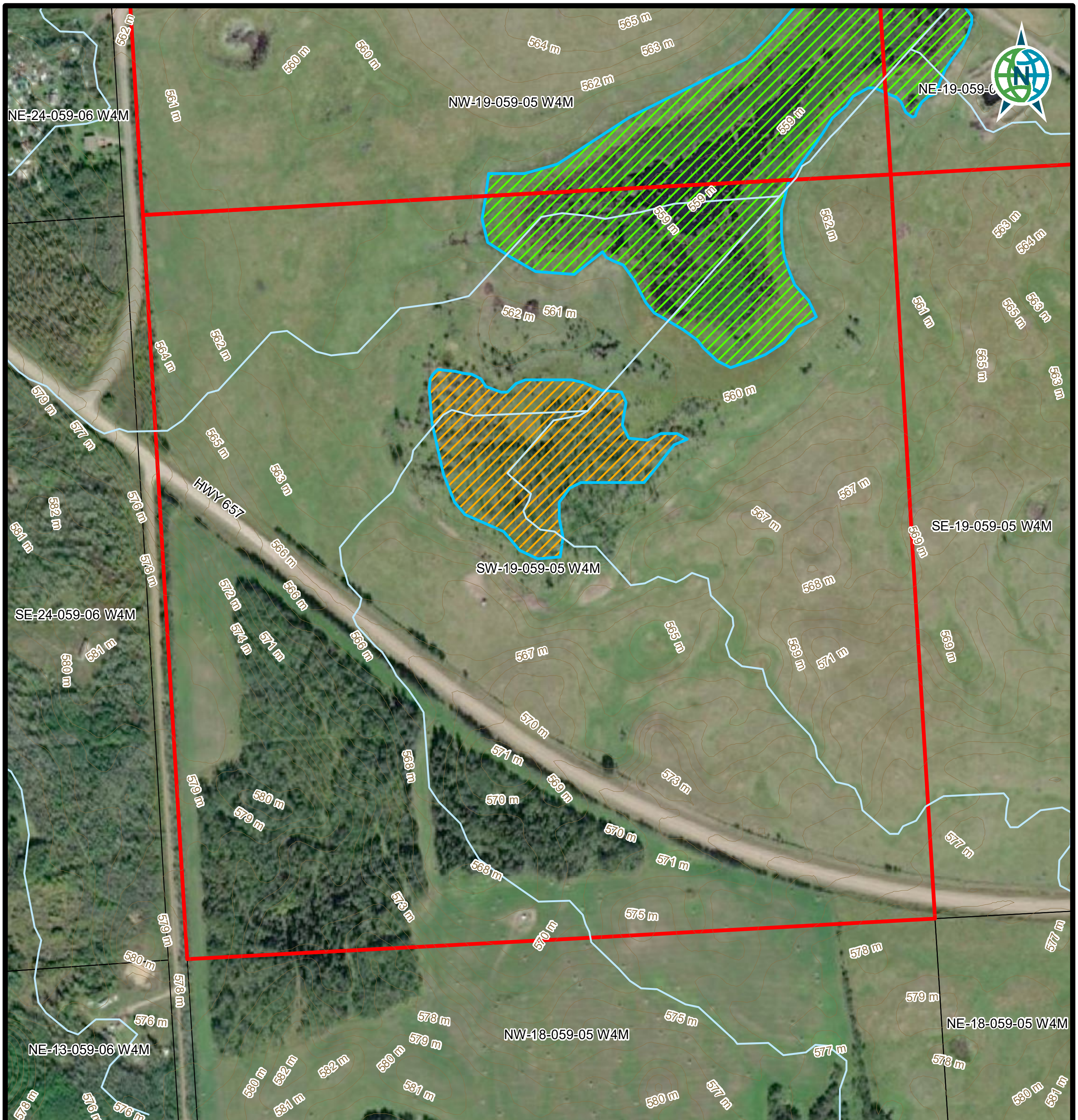
DESKTOP WETLAND ASSESSMENT FOR NE-19-059-05 W4M (LOCATION #1)

DATE:	PROJECTION:	DATUM:
OCTOBER 19, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:6,000

FIGURE A02



LEGEND

- Contour (1m interval)
- Predicted Drainage Path
- Project Area
- Quater Section Boundary
- Wetland Extent

Wetland Class

- Fen
- Marsh
- Swamp
- Water

SOURCES:
HYDROLOGY DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE – ALBERTA.
IMAGERY FROM ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY. IMAGERY DATE: 2013

0 50 100 m

Muriel Lake
Basin Management Society

SOLSTICE
Environmental Management

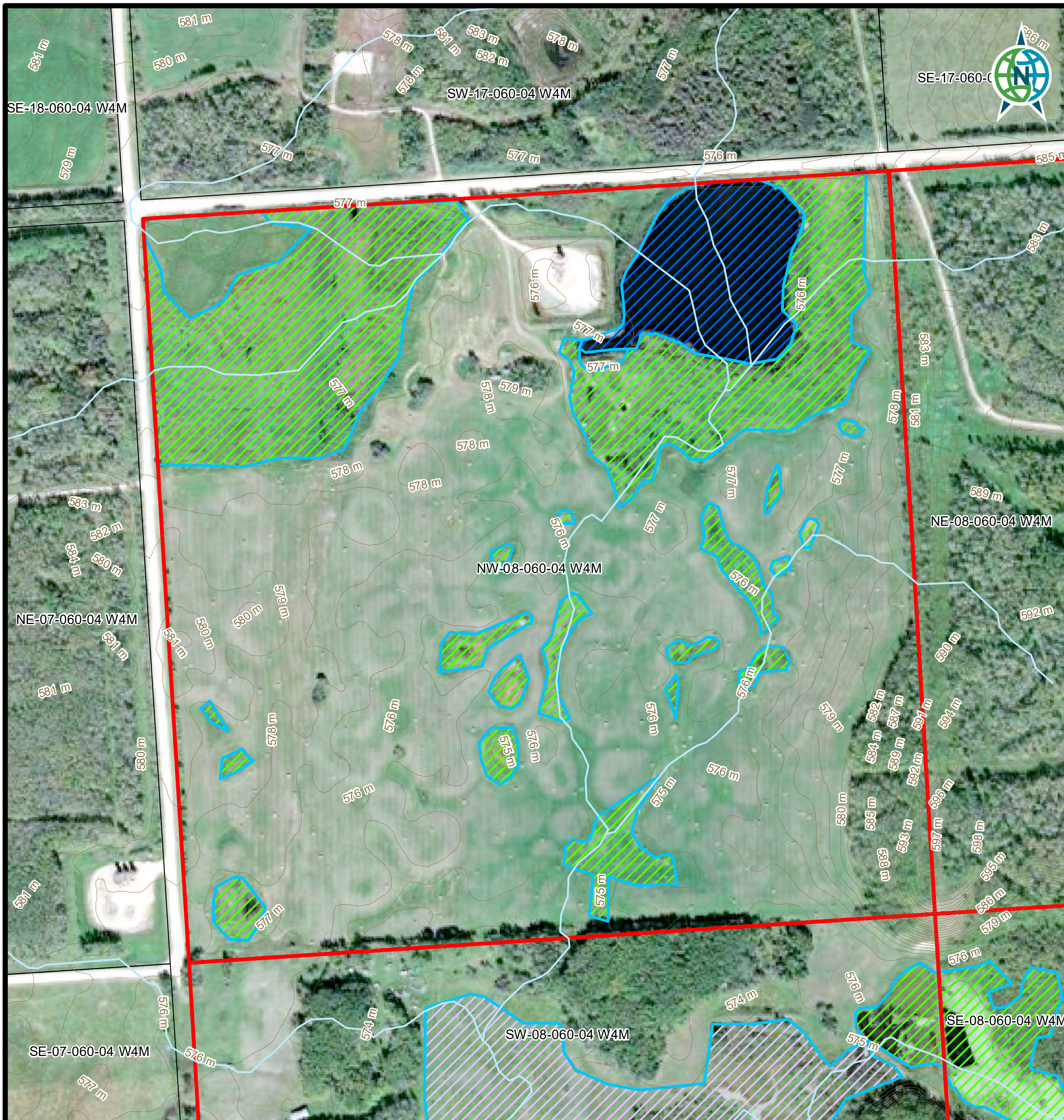
DESKTOP WETLAND ASSESSMENT FOR SW-19-059-05 W4M (LOCATION #1)

DATE:	PROJECTION:	DATUM:
OCTOBER 19, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:6,000

FIGURE A03



LEGEND

- Contour (1m interval)
- Predicted Drainage Path
- Project Area
- Quater Section Boundary
- Wetland Extent

Wetland Class

- Fen
- Marsh
- Swamp
- Water

SOURCES:
HYDROLOGY DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE – ALBERTA.
IMAGERY FROM ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY. IMAGERY DATE: 2017

0 50 100 m

Muriel Lake Basin Management Society

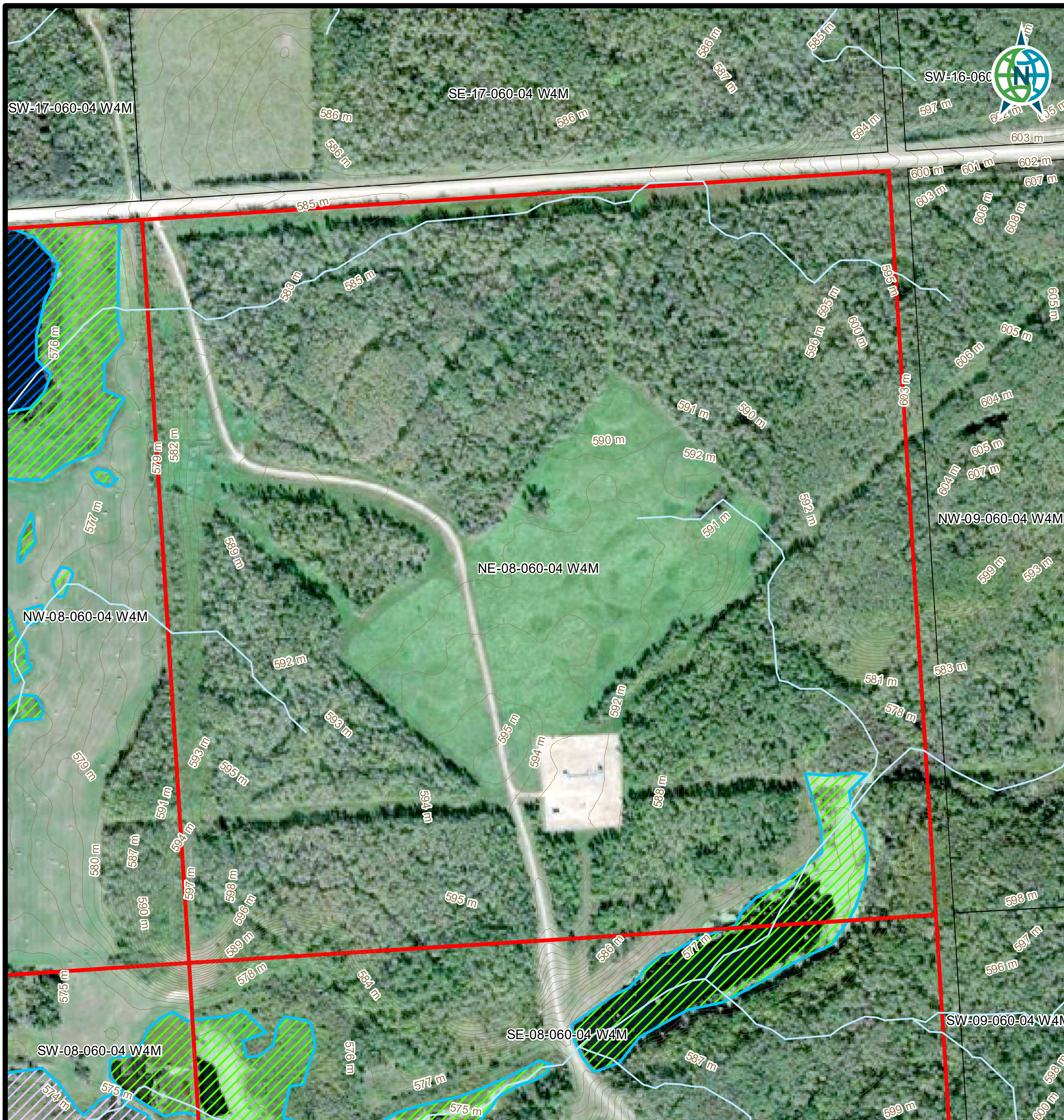
SOLSTICE Environmental Management

DESKTOP WETLAND ASSESSMENT FOR NW-08-060-04 W4M (LOCATION #2)

DATE:	PROJECTION:	DATUM:
OCTOBER 19, 2021	10TM AEP FOREST	NAD83

PROJECT CODE:	SCALE:
20-13135-42	1:6,000

FIGURE A04



LEGEND

- Contour (1m interval)
- Predicted Drainage Path
- Project Area
- Quater Section Boundary
- Wetland Extent

Wetland Class

- Fen
- Marsh
- Swamp
- Water

SOURCES:
HYDROLOGY DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE – ALBERTA.
IMAGERY FROM ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY. IMAGERY DATE: 2017

0 50 100 m

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Basin Management Society

SOLSTICE
Environmental Management

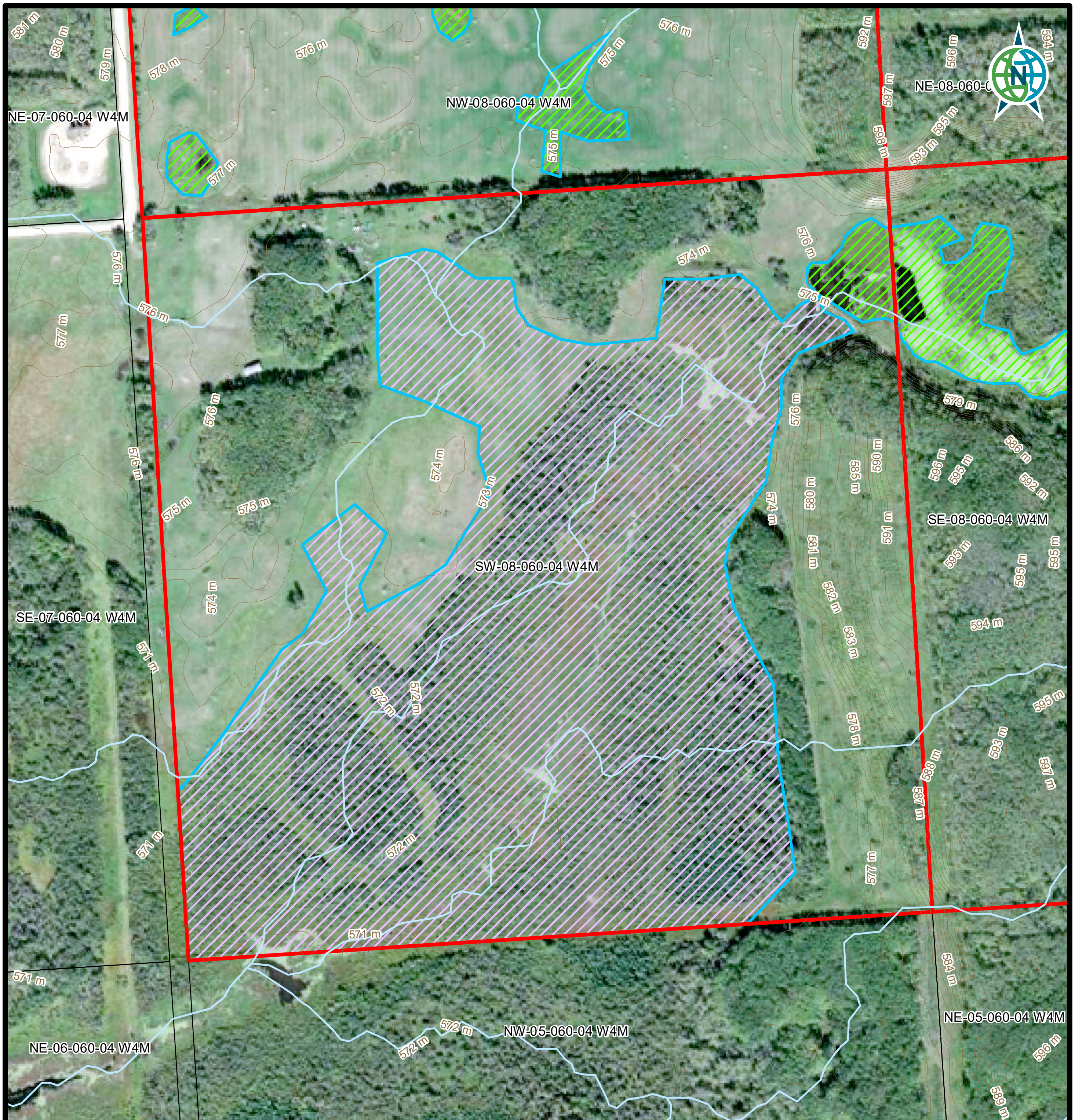
DESKTOP WETLAND ASSESSMENT FOR NE-08-060-04 W4M (LOCATION #2)

DATE:	PROJECTION:	DATUM:
OCTOBER 19, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:6,000

FIGURE A05



LEGEND

- Contour (1m interval)
- Predicted Drainage Path
- Project Area
- Quater Section Boundary
- Wetland Extent

Wetland Class

- Fen
- Marsh
- Swamp
- Water

SOURCES:
HYDROLOGY DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE – ALBERTA.
IMAGERY FROM ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY. IMAGERY DATE: 2017

0 50 100 m

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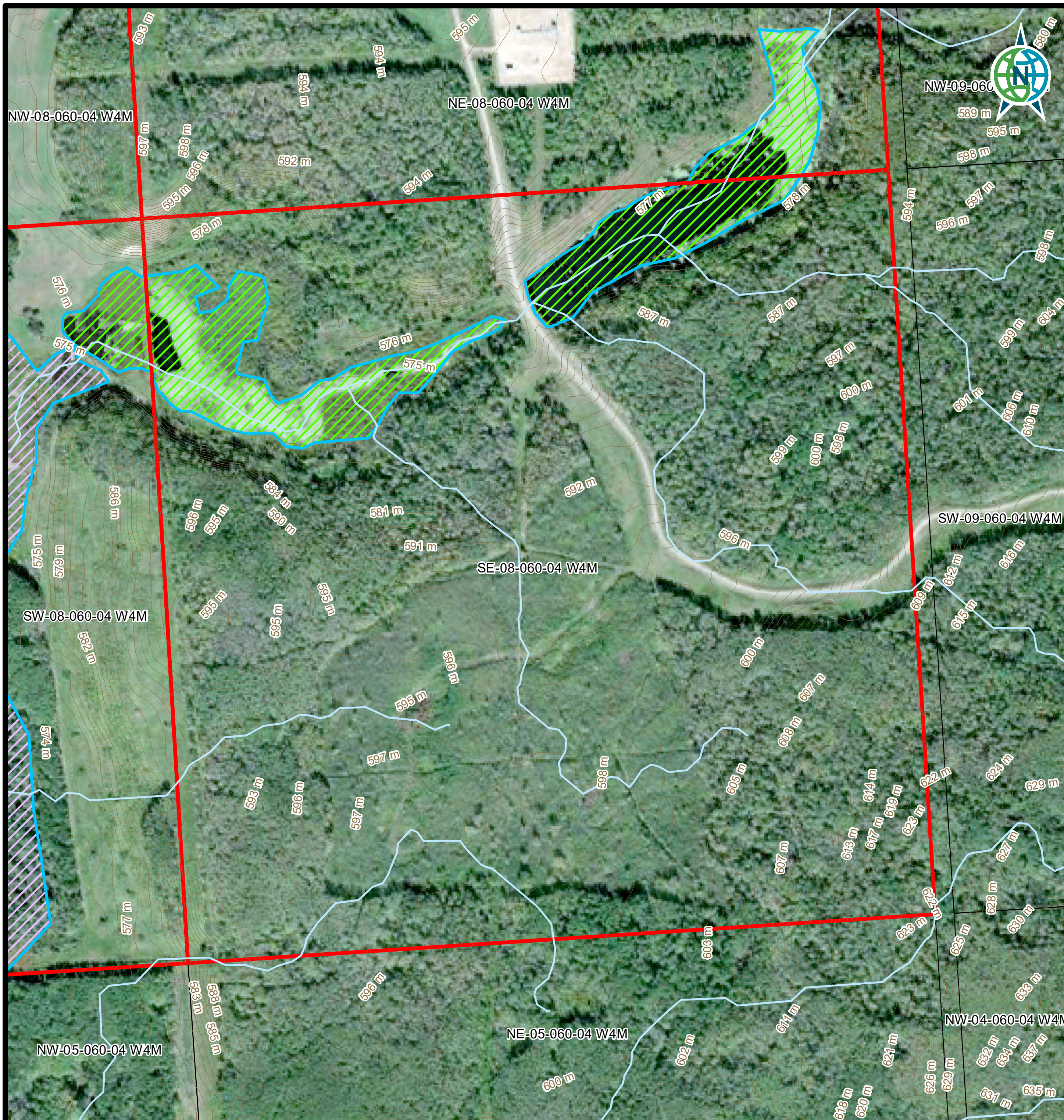
Basin Management Society

SOLSTICE
Environmental Management

DESKTOP WETLAND ASSESSMENT FOR SW-08-060-04 W4M (LOCATION #2)

DATE:	PROJECTION:	DATUM:
OCTOBER 19, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42	**FIGURE A06**
SCALE: 1:6,000	



LEGEND

- Contour (1m interval)
- Predicted Drainage Path
- Project Area
- Quater Section Boundary
- Wetland Extent

Wetland Class

- Fen
- Marsh
- Swamp
- Water

SOURCES:
HYDROLOGY DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE – ALBERTA.
IMAGERY FROM ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY. IMAGERY DATE: 2017

0 50 100 m

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DESKTOP WETLAND ASSESSMENT FOR SE-08-060-04 W4M (LOCATION #2)

DATE:	PROJECTION:	DATUM:
OCTOBER 19, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:6,000

FIGURE A07

LEGEND

Contour (1m interval)
Predicted Drainage Path
Project Area
Quater Section Boundary
Wetland Extent

Wetland Class

Fen
Marsh
Swamp
Water

SOURCES:
HYDROLOGY DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE – ALBERTA.
IMAGERY FROM ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY. IMAGERY DATE: 2013

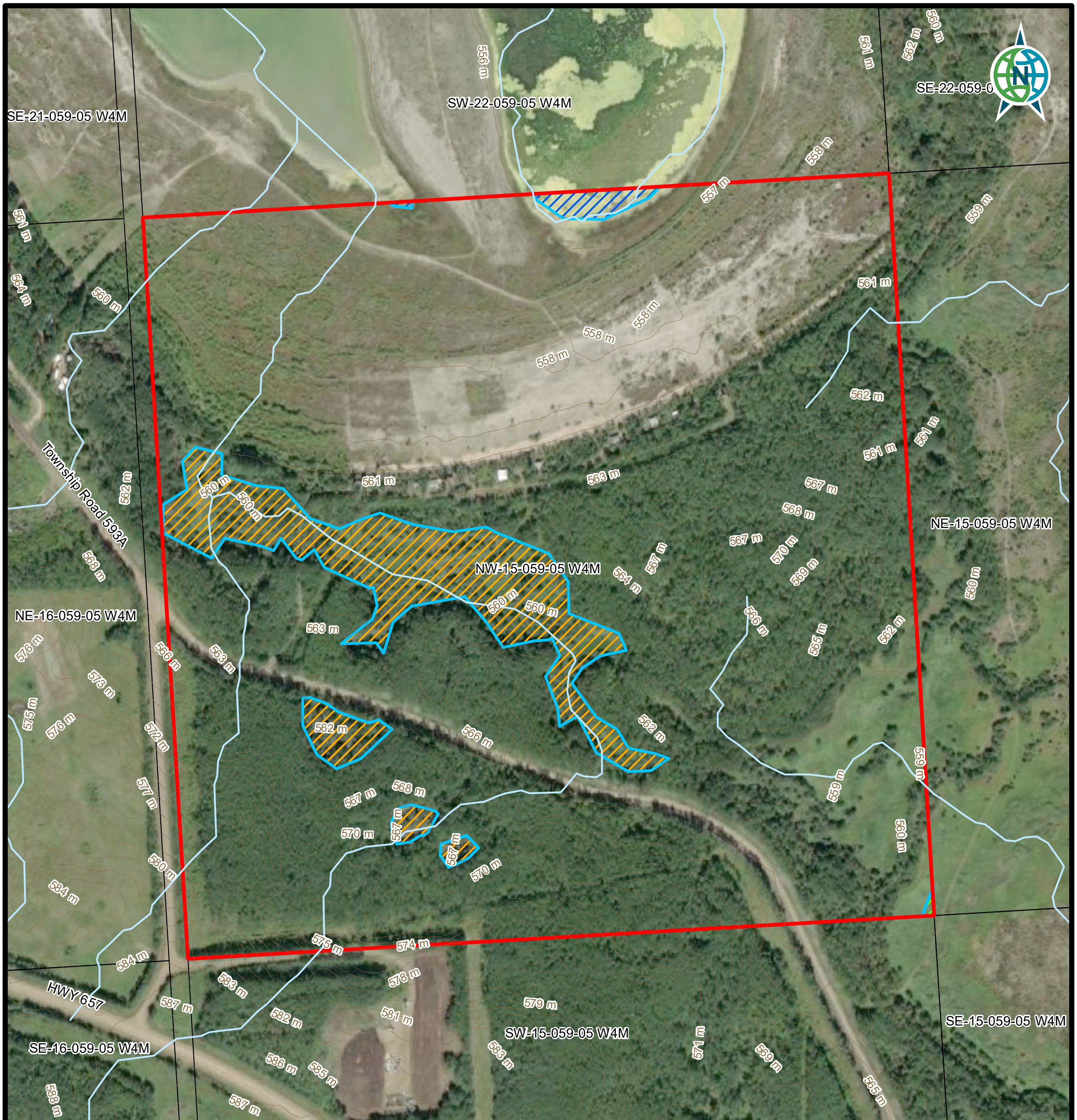
0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

DESKTOP WETLAND ASSESSMENT FOR SE-01-060-05 W4M (LOCATION #3)

DATE:	PROJECTION:	DATUM:
OCTOBER 19, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	**FIGURE A08**	
SCALE: 1:6,000		



LEGEND

- Contour (1m interval)
- Predicted Drainage Path
- Project Area
- Quater Section Boundary
- Wetland Extent

Wetland Class

- Fen
- Marsh
- Swamp
- Water

SOURCES:
HYDROLOGY DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE – ALBERTA.
IMAGERY FROM ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY. IMAGERY DATE: 2013

0 50 100 m

Muriel Lake
Basin Management Society

SOLSTICE
Environmental Management

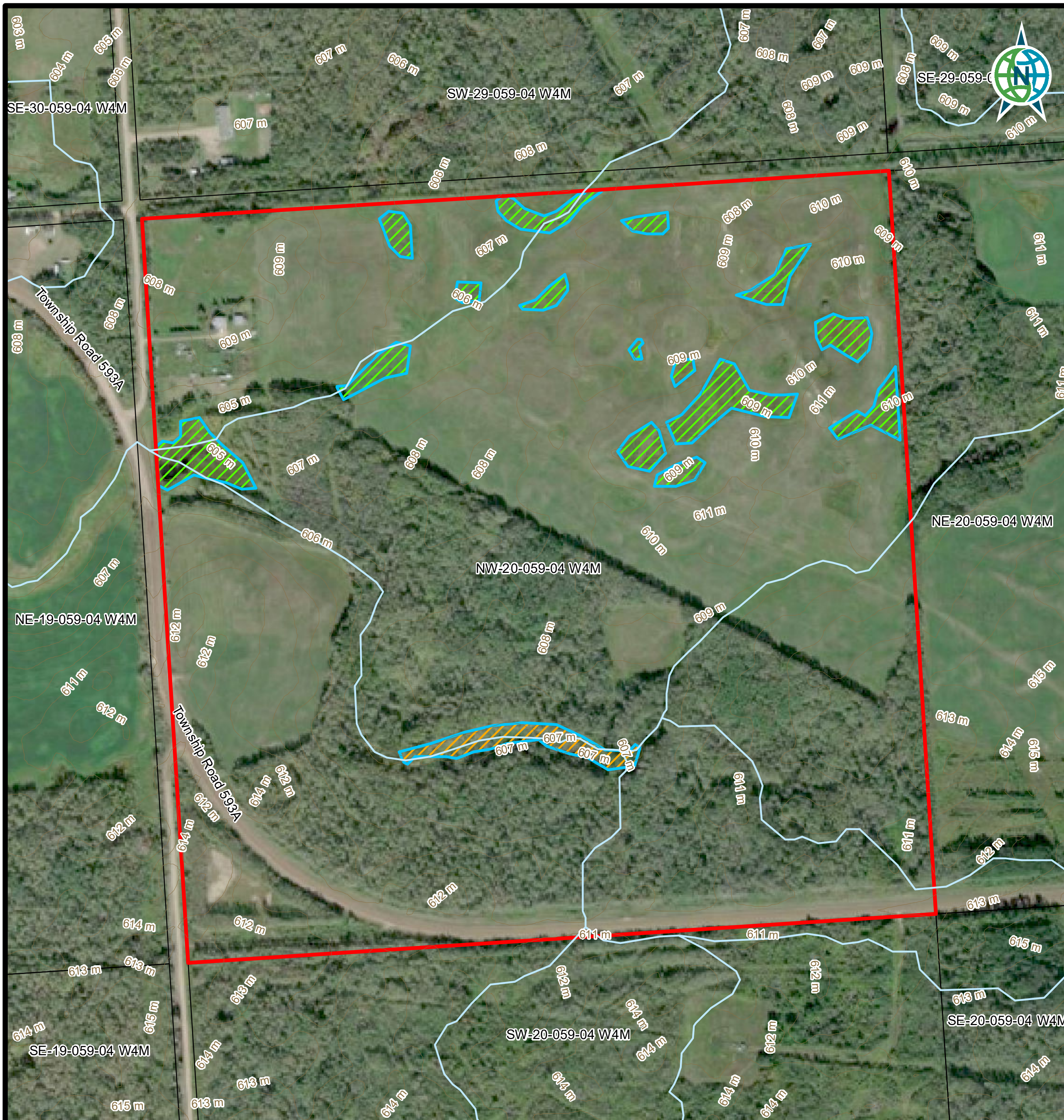
DESKTOP WETLAND ASSESSMENT FOR NW-15-059-05 W4M (LOCATION #4)

DATE:	PROJECTION:	DATUM:
OCTOBER 19, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:6,000

FIGURE A09



LEGEND

- Contour (1m interval)
- Predicted Drainage Path
- Project Area
- Quater Section Boundary
- Wetland Extent

Wetland Class

- Fen
- Marsh
- Swamp
- Water

SOURCES:
HYDROLOGY DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE – ALBERTA.
IMAGERY FROM ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY. IMAGERY DATE: 2017

0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

DESKTOP WETLAND ASSESSMENT FOR NW-20-059-04 W4M (LOCATION #5)

DATE:	PROJECTION:	DATUM:
OCTOBER 19, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:6,000

FIGURE A10

APPENDIX B. CATCHMENT AREAS AND PREDICTED STREAMLINES OF MURIEL LAKE WATERSHED

LEGEND

- Contour (1m interval)
- Predicted Streamline (Location 1)
- Subcatchments (Location 1)
- Subcatchments (others)
- Quater Section Boundary

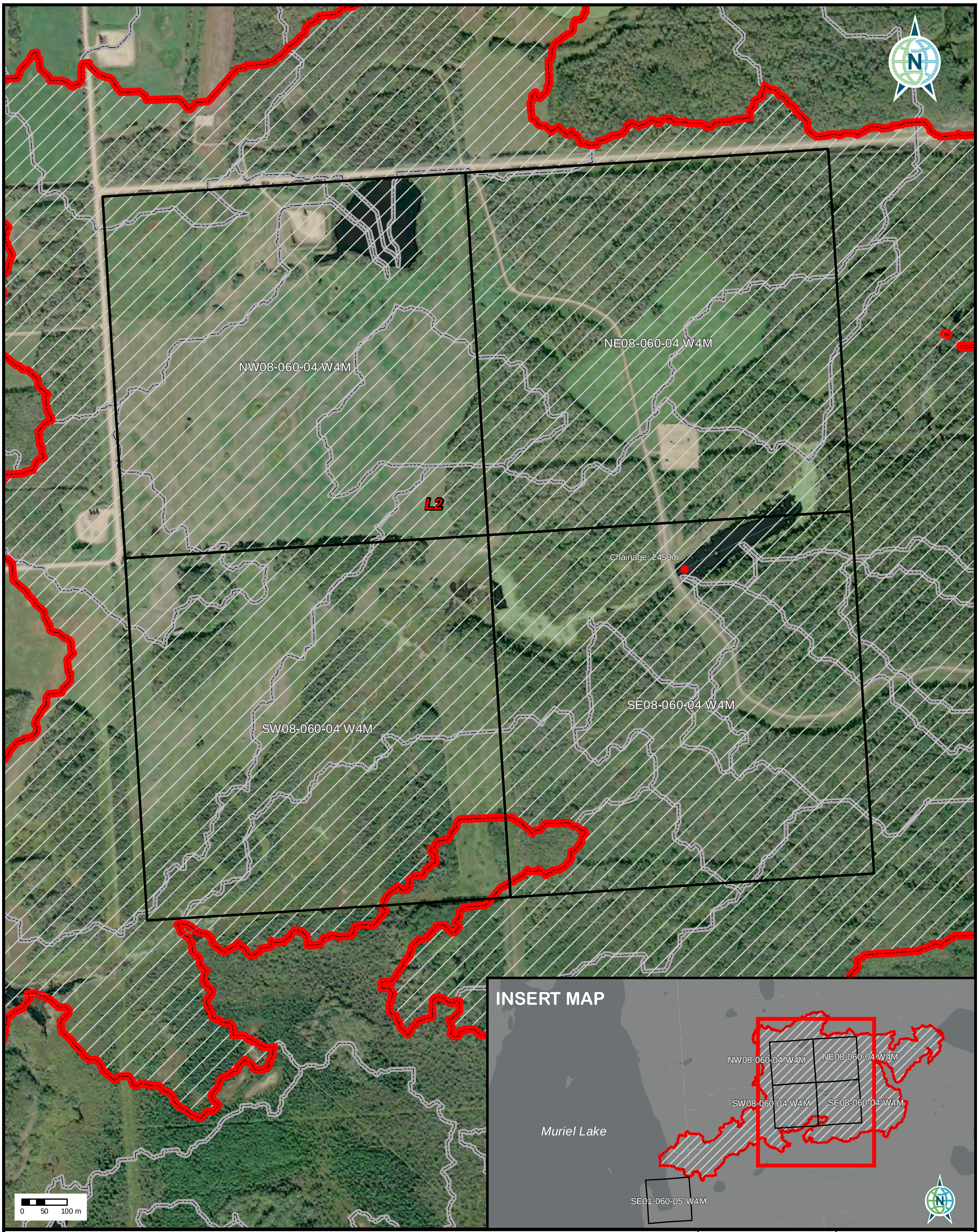
SOURCE:
ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES /AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY, DATE: 24 AUGUST 2013

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NW, NE, SW -19-059-05 W4M
LOCATION 1

DATE: OCTOBER 19, 2021	PROJECTION: 10TM AEP FOREST	DATUM: NAD83
PROJECT CODE: 20-13135-42	FIGURE B01	
SCALE: 1:6,500		



LEGEND

- ML 6 (chainage 2450m)
- Contour (1m interval)
- Predicted Streamline (Location 2)
- Subcatchment (Location 2)
- Subcatchments (others)
- Quater Section Boundary

SOURCE:
ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES /AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY, DATE: 5 SEPTEMBER 2017

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NW, NE, SW & SE-08-060-04 W4M
LOCATION 2

DATE:	PROJECTION:	DATUM:
OCTOBER 19, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:8,000

FIGURE B04

LEGEND

- Contour (1m interval)
- Predicted Streamline (Location 3)
- Subcatchment (Location 3)
- Subcatchments (others)
- Quater Section Boundary

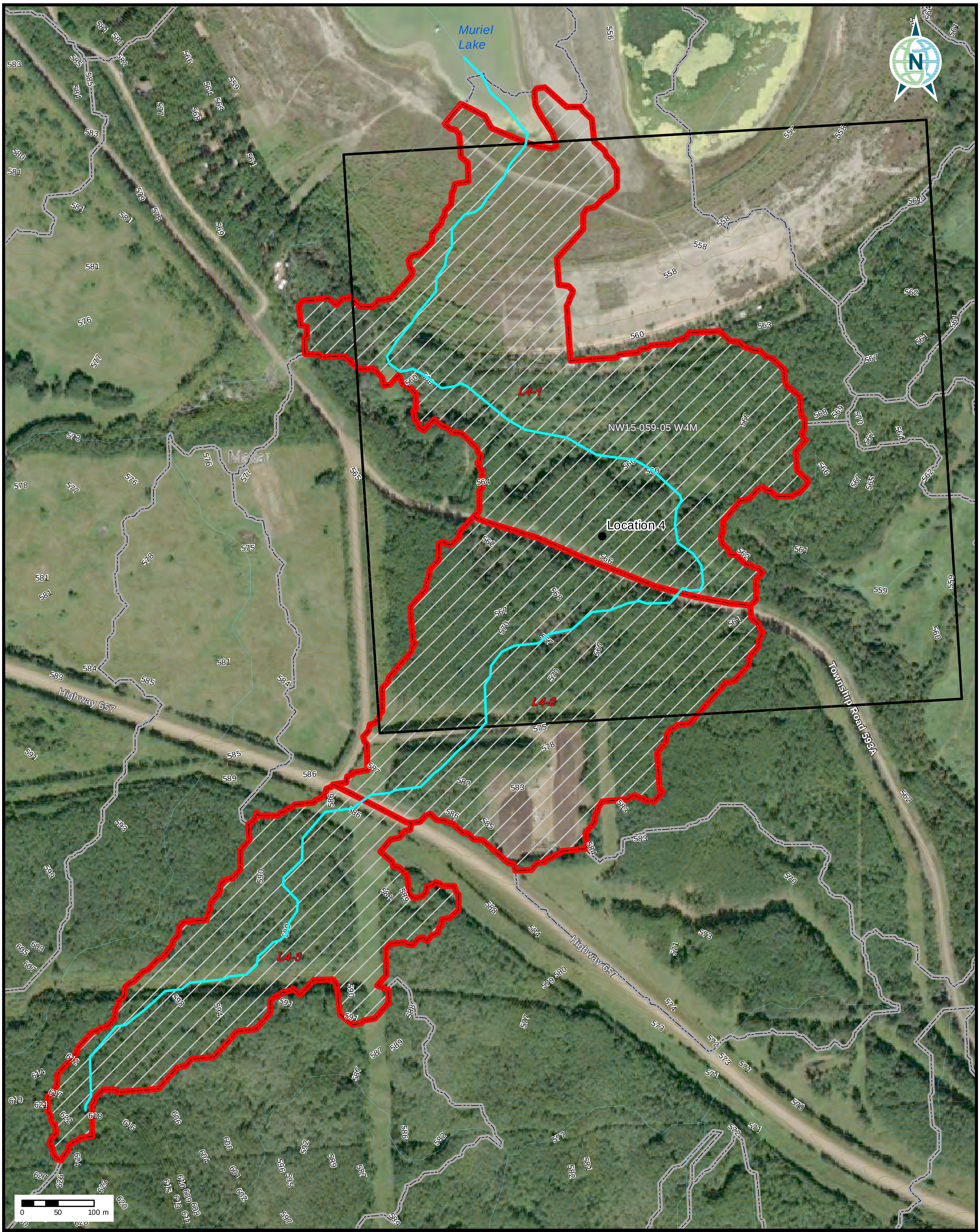
SOURCE:
ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES /AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY, DATES: 24 AUGUST, 2013 AND 5 SEPTEMBER 2017

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
SE-01-060-05 W4M
LOCATION 3

DATE:	PROJECTION:	DATUM:
OCTOBER 19, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	**FIGURE B03**	
SCALE: 1:6,000		



LEGEND

- Location 4
- Contour (1m interval)
- Predicted Streamline (Location 4)
- Subcatchments (Location 4)
- Subcatchments (others)
- Quater Section Boundary

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

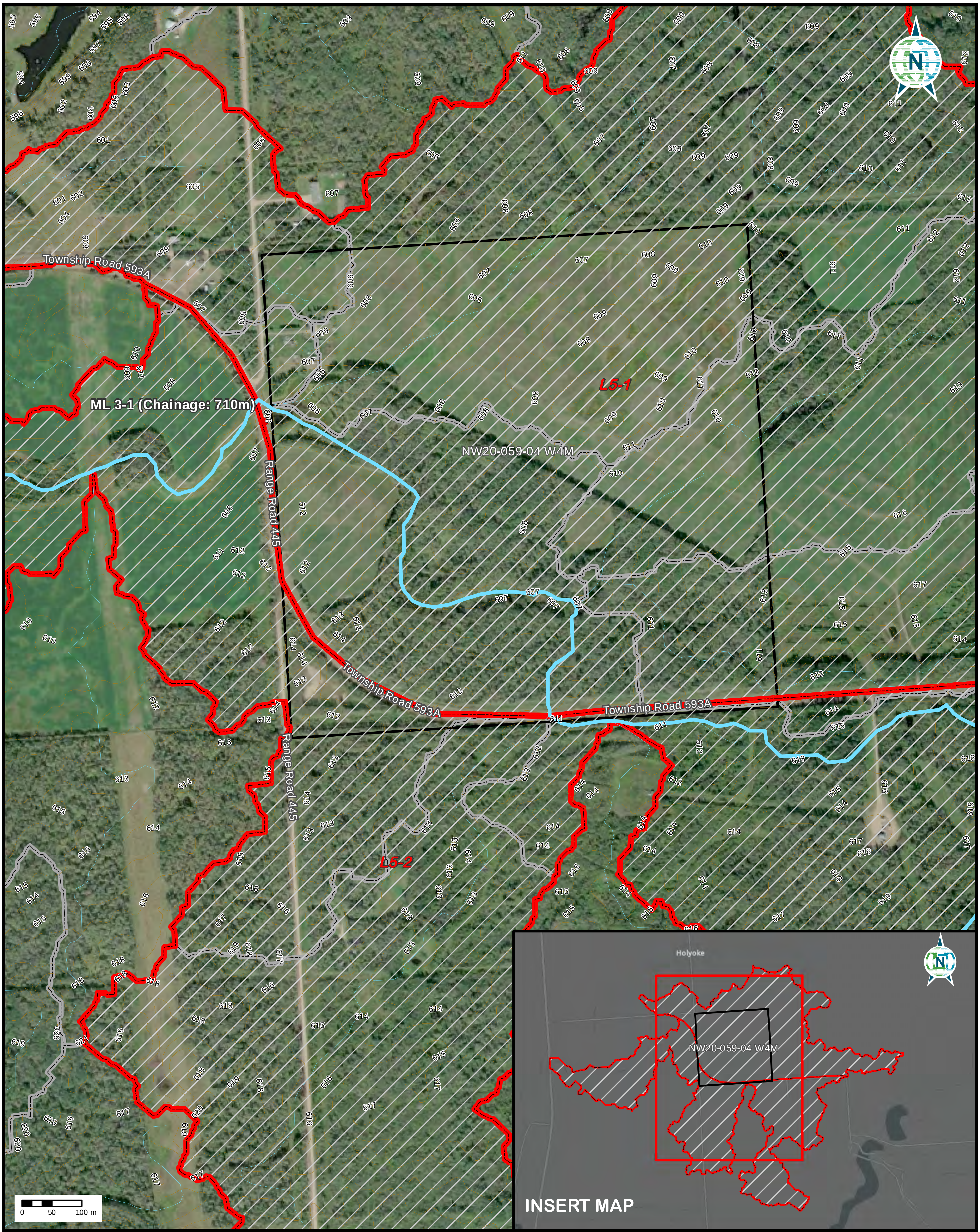
MURIEL LAKE

NW-15-059-05 W4M

LOCATION 4

DATE:	PROJECTION:	DATUM:
OCTOBER 19, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	**FIGURE B04**	
SCALE: 1:5,000		

SOURCE:
ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES /AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY, DATE: 24 AUGUST 2013



LEGEND

- ML 3-1 (Chainage 710m)
- Contour (1m interval)
- Predicted Streamline
- Subcatchment (Location 5)
- Subcatchments (others)
- Quater Section Boundary

SOURCE:
ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES /AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY, DATE: 5 SEPTEMBER 2017

Muriel Lake Basin Management Society | SOLSTICE Environmental Management

MURIEL LAKE
NW-20-059-04 W4M
LOCATION 5

DATE:	PROJECTION:	DATUM:
OCTOBER 19, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:6,000

FIGURE B05

APPENDIX C. ANNUAL PRECIPITATION RECORDS FOR LOCATIONS #1 AND #4

APPENDIX C. Annual Precipitation Records for Locations 1 and 4

Yearly Precipitation Data[1]			
Township	**Date[2]**	**Precipitation (mm)**	**Dry/Wet[3]**
T059R05W4	1955	491.31	Wet
T059R05W4	1956	493.08	Wet
T059R05W4	1957	396.53	Normal
T059R05W4	1958	322.41	Dry
T059R05W4	1959	443.92	Normal
T059R05W4	1960	580.60	Wet
T059R05W4	1961	337.91	Dry
T059R05W4	1962	540.13	Wet
T059R05W4	1963	341.05	Dry
T059R05W4	1964	475.58	Wet
T059R05W4	1965	490.83	Wet
T059R05W4	1966	328.44	Dry
T059R05W4	1967	340.39	Dry
T059R05W4	1968	426.23	Normal
T059R05W4	1969	433.39	Normal
T059R05W4	1970	551.74	Wet
T059R05W4	1971	441.70	Normal
T059R05W4	1972	374.93	Dry
T059R05W4	1973	591.26	Wet
T059R05W4	1974	471.75	Wet
T059R05W4	1975	458.89	Normal
T059R05W4	1976	415.59	Normal
T059R05W4	1977	519.83	Wet
T059R05W4	1978	455.63	Normal
T059R05W4	1979	457.57	Normal
T059R05W4	1980	401.72	Normal
T059R05W4	1981	338.77	Dry
T059R05W4	1982	424.42	Normal
T059R05W4	1983	446.09	Normal
T059R05W4	1984	457.81	Normal
T059R05W4	1985	351.68	Dry
T059R05W4	1986	446.77	Normal
T059R05W4	1987	324.36	Dry
T059R05W4	1988	503.74	Wet
T059R05W4	1989	477.40	Wet
T059R05W4	1990	385.00	Dry
T059R05W4	1991	327.56	Dry
T059R05W4	1992	363.31	Dry
T059R05W4	1993	470.77	Wet
T059R05W4	1994	480.86	Wet
T059R05W4	1995	370.71	Dry
T059R05W4	1996	529.82	Wet
T059R05W4	1997	473.62	Wet
T059R05W4	1998	363.13	Dry

APPENDIX C. Annual Precipitation Records for Locations 1 and 4

SOLSTICE Environmental Management

Yearly Precipitation Data[1]			
Township	**Date[2]**	**Precipitation (mm)**	**Dry/Wet[3]**
T059R05W4	1999	359.61	Dry
T059R05W4	2000	427.84	Normal
T059R05W4	2001	351.40	Dry
T059R05W4	2002	255.80	Dry
T059R05W4	2003	471.87	Wet
T059R05W4	2004	443.14	Normal
T059R05W4	2005	418.37	Normal
T059R05W4	2006	405.70	Normal
T059R05W4	2007	406.83	Normal
T059R05W4	2008	295.14	Dry
T059R05W4	2009	294.67	Dry
T059R05W4	2010	458.33	Normal
T059R05W4	2011	419.55	Normal
T059R05W4	2012	497.65	Wet
T059R05W4	2013	337.50	Dry
T059R05W4	2014	422.00	Normal
T059R05W4	2015	339.57	Dry
T059R05W4	2016	463.47	Wet
T059R05W4	2017	491.83	Wet
T059R05W4	2018	420.21	Normal
T059R05W4	2019	399.30	Normal
	Average	**423.05**	
	Std Dev	**71.80**	
	Maximum Range of 'Normal' (mean + 0.5 Std Dev)	**458.94**	
	Minimum Range of 'Normal' (mean - 0.5 Std Dev)	**387.15**	

[1]AAF (c2020) maintains historical climatology records from weather stations across the country. The historical monthly records for the nearest stations were reviewed to determine annual precipitation (January-December).

[2]No precipitation data is available prior to 1955.

[3]Dry, Wet, and Normal years were determined relative to the averaged precipitation levels over the period from 1955-2019 in this area (423 mm).

APPENDIX D. ANNUAL PRECIPITATION RECORDS FOR LOCATION #2

APPENDIX D. Annual Precipitation Records for Location 2

SOLSTICE Environmental Management

Yearly Precipitation Data[1]			
Township	Date[2]	Precipitation (mm)	Dry/Wet[3]
T060R04W4	1955	499.12	Wet
T060R04W4	1956	476.02	Wet
T060R04W4	1957	429.61	Normal
T060R04W4	1958	370.94	Dry
T060R04W4	1959	436.09	Normal
T060R04W4	1960	600.21	Wet
T060R04W4	1961	357.80	Dry
T060R04W4	1962	560.49	Wet
T060R04W4	1963	346.81	Dry
T060R04W4	1964	469.01	Wet
T060R04W4	1965	476.02	Wet
T060R04W4	1966	330.13	Dry
T060R04W4	1967	321.60	Dry
T060R04W4	1968	420.35	Normal
T060R04W4	1969	442.49	Normal
T060R04W4	1970	555.61	Wet
T060R04W4	1971	435.04	Normal
T060R04W4	1972	382.18	Dry
T060R04W4	1973	594.79	Wet
T060R04W4	1974	483.71	Wet
T060R04W4	1975	472.70	Wet
T060R04W4	1976	417.83	Normal
T060R04W4	1977	470.73	Wet
T060R04W4	1978	391.67	Normal
T060R04W4	1979	429.61	Normal
T060R04W4	1980	416.35	Normal
T060R04W4	1981	321.65	Dry
T060R04W4	1982	380.33	Dry
T060R04W4	1983	384.67	Dry
T060R04W4	1984	467.91	Wet
T060R04W4	1985	345.27	Dry
T060R04W4	1986	430.90	Normal
T060R04W4	1987	378.66	Dry
T060R04W4	1988	495.58	Wet
T060R04W4	1989	466.26	Wet
T060R04W4	1990	397.55	Normal
T060R04W4	1991	324.52	Dry
T060R04W4	1992	366.62	Dry
T060R04W4	1993	476.56	Wet
T060R04W4	1994	440.70	Normal
T060R04W4	1995	406.12	Normal
T060R04W4	1996	512.98	Wet
T060R04W4	1997	503.31	Wet
T060R04W4	1998	419.59	Normal

APPENDIX D. Annual Precipitation Records for Location 2

SOLSTICE Environmental Management

Yearly Precipitation Data[1]			
Township	Date[2]	Precipitation (mm)	Dry/Wet[3]
T060R04W4	1999	327.19	Dry
T060R04W4	2000	393.90	Normal
T060R04W4	2001	362.87	Dry
T060R04W4	2002	268.42	Dry
T060R04W4	2003	547.34	Wet
T060R04W4	2004	457.09	Normal
T060R04W4	2005	454.70	Normal
T060R04W4	2006	417.14	Normal
T060R04W4	2007	430.31	Normal
T060R04W4	2008	323.86	Dry
T060R04W4	2009	309.27	Dry
T060R04W4	2010	492.26	Wet
T060R04W4	2011	409.03	Normal
T060R04W4	2012	472.58	Wet
T060R04W4	2013	327.80	Dry
T060R04W4	2014	392.07	Normal
T060R04W4	2015	352.84	Dry
T060R04W4	2016	464.76	Wet
T060R04W4	2017	497.38	Wet
T060R04W4	2018	422.37	Normal
T060R04W4	2019	421.00	Normal
	Average	425.39	
	Std Dev	70.62	
	Maximum Range of 'Normal' (mean + 0.5 Std Dev)	460.70	
	Minimum Range of 'Normal' (mean - 0.5 Std Dev)	390.08	

[1]AAF (c2020) maintains historical climatology records from weather stations across the country. The historical monthly records for the nearest stations were reviewed to determine annual precipitation (January-December).

[2]No precipitation data is available prior to 1955.

[3]Dry, Wet, and Normal years were determined relative to the averaged precipitation levels over the period from 1955-2019 in this area (425 mm).

APPENDIX E. ANNUAL PRECIPITATION RECORDS FOR LOCATION #3

SOLSTICE Environmental Management

Yearly Precipitation Data[1]			
Township	Date[2]	Precipitation (mm)	Dry/Wet[3]
T060R05W4	1955	492.65	Wet
T060R05W4	1956	476.47	Wet
T060R05W4	1957	402.16	Normal
T060R05W4	1958	334.35	Dry
T060R05W4	1959	415.57	Normal
T060R05W4	1960	584.75	Wet
T060R05W4	1961	348.42	Dry
T060R05W4	1962	549.22	Wet
T060R05W4	1963	337.96	Dry
T060R05W4	1964	478.37	Wet
T060R05W4	1965	477.38	Wet
T060R05W4	1966	330.70	Dry
T060R05W4	1967	317.17	Dry
T060R05W4	1968	418.91	Normal
T060R05W4	1969	447.87	Normal
T060R05W4	1970	554.69	Wet
T060R05W4	1971	419.36	Normal
T060R05W4	1972	371.58	Dry
T060R05W4	1973	612.25	Wet
T060R05W4	1974	460.69	Normal
T060R05W4	1975	473.28	Wet
T060R05W4	1976	423.05	Normal
T060R05W4	1977	503.46	Wet
T060R05W4	1978	447.57	Normal
T060R05W4	1979	447.31	Normal
T060R05W4	1980	412.54	Normal
T060R05W4	1981	340.24	Dry
T060R05W4	1982	418.00	Normal
T060R05W4	1983	430.67	Normal
T060R05W4	1984	469.53	Wet
T060R05W4	1985	354.22	Dry
T060R05W4	1986	446.26	Normal
T060R05W4	1987	349.46	Dry
T060R05W4	1988	494.19	Wet
T060R05W4	1989	468.95	Wet
T060R05W4	1990	403.79	Normal
T060R05W4	1991	331.97	Dry
T060R05W4	1992	373.30	Dry
T060R05W4	1993	486.75	Wet
T060R05W4	1994	460.52	Normal
T060R05W4	1995	406.69	Normal
T060R05W4	1996	548.32	Wet
T060R05W4	1997	525.54	Wet
T060R05W4	1998	396.78	Normal

APPENDIX E. Annual Precipitation Records for Location 3

SOLSTICE Environmental Management

Yearly Precipitation Data[1]			
Township	Date[2]	Precipitation (mm)	Dry/Wet[3]
T060R05W4	1999	339.82	Dry
T060R05W4	2000	440.19	Normal
T060R05W4	2001	384.34	Dry
T060R05W4	2002	275.06	Dry
T060R05W4	2003	517.88	Wet
T060R05W4	2004	466.15	Wet
T060R05W4	2005	435.82	Normal
T060R05W4	2006	418.51	Normal
T060R05W4	2007	425.41	Normal
T060R05W4	2008	315.37	Dry
T060R05W4	2009	291.81	Dry
T060R05W4	2010	468.92	Wet
T060R05W4	2011	403.87	Normal
T060R05W4	2012	460.56	Normal
T060R05W4	2013	347.59	Dry
T060R05W4	2014	424.09	Normal
T060R05W4	2015	351.87	Dry
T060R05W4	2016	458.26	Normal
T060R05W4	2017	490.90	Wet
T060R05W4	2018	420.11	Normal
T060R05W4	2019	387.78	Dry
	Average	427.19	
	Std Dev	70.89	
	Maximum Range of 'Normal' (mean + 0.5 Std Dev)	462.63	
	Minimum Range of 'Normal' (mean - 0.5 Std Dev)	391.74	

[1]AAF (c2020) maintains historical climatology records from weather stations across the country. The historical monthly records for the nearest stations were reviewed to determine annual precipitation (January-December).

[2]No precipitation data is available prior to 1955.

[3]Dry, Wet, and Normal years were determined relative to the averaged precipitation levels over the period from 1955-2019 in this area (427 mm).

APPENDIX F. ANNUAL PRECIPITATION RECORDS FOR LOCATION #5

APPENDIX F. Annual Precipitation Records for Location 5

SOLSTICE Environmental Management

Yearly Precipitation Data[1]			
Township	Date[2]	Precipitation (mm)	Dry/Wet[3]
T059R04W4	1955	493.55	Wet
T059R04W4	1956	484.95	Wet
T059R04W4	1957	406.48	Normal
T059R04W4	1958	334.38	Dry
T059R04W4	1959	448.18	Normal
T059R04W4	1960	592.31	Wet
T059R04W4	1961	356.38	Dry
T059R04W4	1962	546.20	Wet
T059R04W4	1963	351.87	Dry
T059R04W4	1964	470.04	Wet
T059R04W4	1965	485.51	Wet
T059R04W4	1966	331.27	Dry
T059R04W4	1967	337.89	Dry
T059R04W4	1968	428.37	Normal
T059R04W4	1969	433.80	Normal
T059R04W4	1970	539.37	Wet
T059R04W4	1971	447.18	Normal
T059R04W4	1972	383.40	Normal
T059R04W4	1973	569.82	Wet
T059R04W4	1974	472.13	Wet
T059R04W4	1975	448.64	Normal
T059R04W4	1976	401.92	Normal
T059R04W4	1977	510.04	Wet
T059R04W4	1978	413.59	Normal
T059R04W4	1979	445.54	Normal
T059R04W4	1980	396.80	Normal
T059R04W4	1981	305.81	Dry
T059R04W4	1982	395.85	Normal
T059R04W4	1983	396.02	Normal
T059R04W4	1984	457.53	Wet
T059R04W4	1985	343.68	Dry
T059R04W4	1986	453.74	Normal
T059R04W4	1987	332.92	Dry
T059R04W4	1988	503.55	Wet
T059R04W4	1989	462.59	Wet
T059R04W4	1990	371.13	Dry
T059R04W4	1991	330.78	Dry
T059R04W4	1992	347.79	Dry
T059R04W4	1993	458.97	Wet
T059R04W4	1994	469.22	Wet
T059R04W4	1995	377.43	Dry
T059R04W4	1996	499.71	Wet
T059R04W4	1997	445.20	Normal
T059R04W4	1998	381.99	Dry

APPENDIX F. Annual Precipitation Records for Location 5

Yearly Precipitation Data[1]			
Township	**Date²**	**Precipitation (mm)**	**Dry/Wet³**
T059R04W4	1999	366.76	Dry
T059R04W4	2000	401.49	Normal
T059R04W4	2001	322.39	Dry
T059R04W4	2002	240.00	Dry
T059R04W4	2003	497.28	Wet
T059R04W4	2004	438.76	Normal
T059R04W4	2005	424.46	Normal
T059R04W4	2006	404.99	Normal
T059R04W4	2007	404.14	Normal
T059R04W4	2008	296.56	Dry
T059R04W4	2009	300.48	Dry
T059R04W4	2010	465.02	Wet
T059R04W4	2011	425.71	Normal
T059R04W4	2012	506.73	Wet
T059R04W4	2013	323.16	Dry
T059R04W4	2014	401.35	Normal
T059R04W4	2015	340.40	Dry
T059R04W4	2016	467.20	Wet
T059R04W4	2017	497.33	Wet
T059R04W4	2018	421.32	Normal
T059R04W4	2019	421.15	Normal
	Average	**418.93**	
	Std Dev	**71.23**	
	Maximum Range of 'Normal' (mean + 0.5 Std Dev)	**454.54**	
	Minimum Range of 'Normal' (mean - 0.5 Std Dev)	**383.31**	

¹AAF (c2020) maintains historical climatology records from weather stations across the country. The historical monthly records for the nearest stations were reviewed to determine annual precipitation (January-December).

²No precipitation data is available prior to 1955.

³Dry, Wet, and Normal years were determined relative to the averaged precipitation levels over the period from 1955-2019 in this area (419 mm).

APPENDIX G. HISTORICAL AIR PHOTO REVIEW MAPS

LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 0125 012, ORIGINAL PHOTO SCALE: 1:40,000, DATE: 1949-1950.

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NW-19-059-05 W4M
1949-1950

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	FIGURE A01	
SCALE: 1:6,500		

LEGEND

Site Boundary

Quarter Section Boundary

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NW-19-059-05 W4M
JUNE 1972

DATE: SEPTEMBER 29, 2021	PROJECTION: 10TM AEP FOREST	DATUM: NAD83
PROJECT CODE: 20-13135-42	FIGURE A02	
SCALE: 1:6,500		

0 50 100 m

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 1197 048, ORIGINAL PHOTO SCALE: 1:31,680, DATE: 06/21/1972.

LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.

0 50 100 m

Muriel Lake
Basin Management Society

SOLSTICE
Environmental Management

MURIEL LAKE
NW-19-059-05 W4M
AUGUST 2013

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:6,500

FIGURE A03

LEGEND

- Site Boundary
- Quarter Section Boundary

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 0125 012, ORIGINAL PHOTO SCALE: 1:40,000, DATE: 1949-1950.

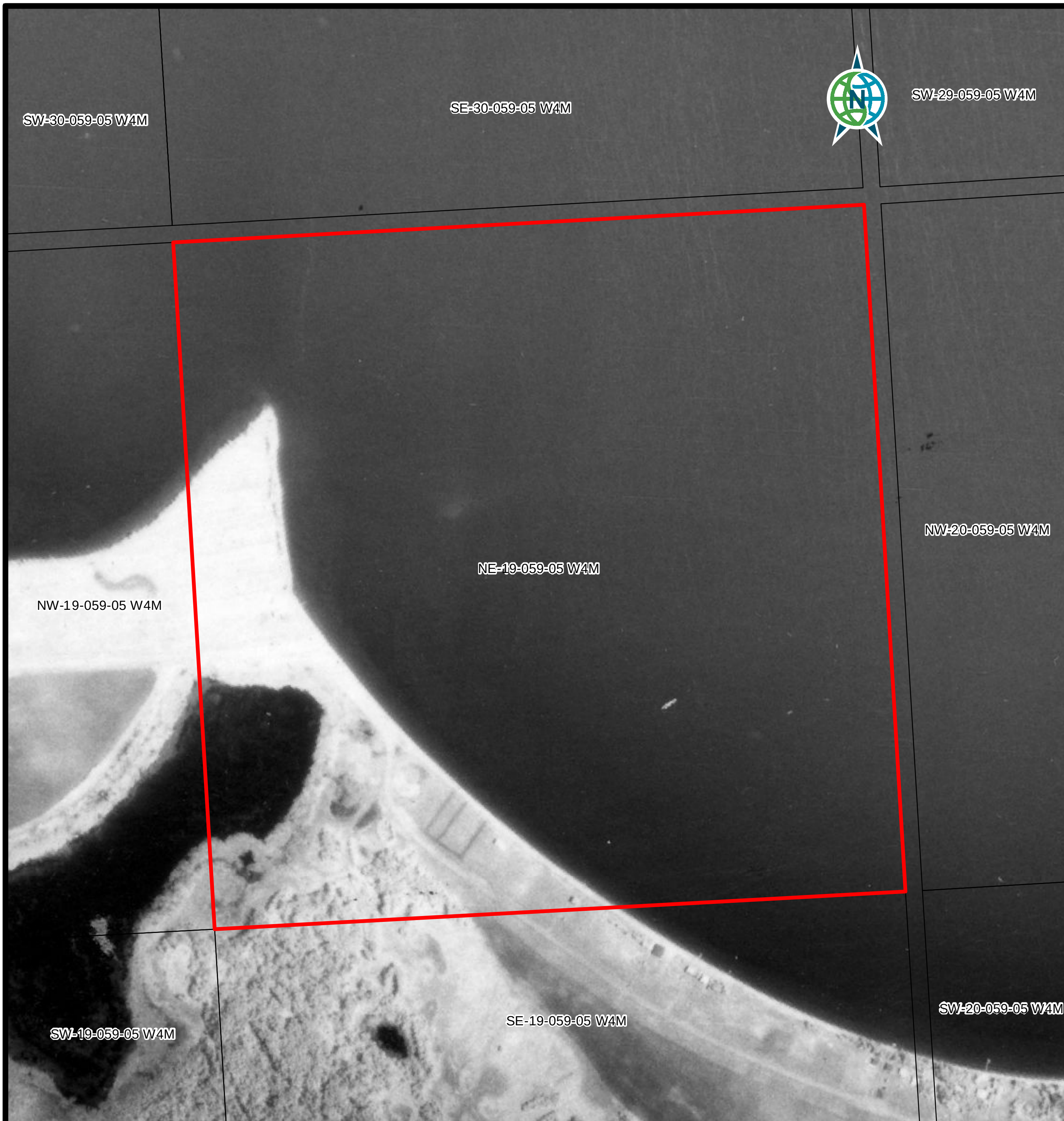
0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NE-19-059-05 W4M
1949-1950

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	FIGURE A04	
SCALE: 1:6,500		



LEGEND

Site Boundary

Quarter Section Boundary

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NE-19-059-05 W4M
JUNE 1972

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	FIGURE A05	
SCALE: 1:6,500		

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 1197 048, ORIGINAL PHOTO SCALE: 1:31,680, DATE: 06/21/1972.

0 50 100 m

LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/ AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.

0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NE-19-059-05 W4M
AUGUST 2013

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	**FIGURE A06**	
SCALE: 1:6,500		

LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 0125 012, ORIGINAL PHOTO SCALE: 1:40,000, DATE: 1949-1950.

0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
SW-19-059-05 W4M
1949-1950

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	FIGURE A07	
SCALE: 1:6,500		

LEGEND

Site Boundary

Quarter Section Boundary

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
SW-19-059-05 W4M
JUNE 1972

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:6,500

FIGURE A08

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 1197 048, ORIGINAL PHOTO SCALE: 1:31,680, DATE: 06/21/1972.

0 50 100 m

LEGEND

Site Boundary

Quarter Section Boundary

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
SW-19-059-05 W4M
AUGUST 2013

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:6,500

0 50 100 m

FIGURE A09

SOURCE:
ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.

LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 0125 013, ORIGINAL PHOTO SCALE: 1:40,000, DATE: 1949-1950.

0 50 100 m

Muriel Lake
Basin Management Society

SOLSTICE
Environmental Management

MURIEL LAKE
NW-15-059-05 W4M
1949-1950

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	FIGURE A10	
SCALE: 1:6,500		

LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 1197 052, ORIGINAL PHOTO SCALE: 1:31,680, DATE: 09/04/1972.

0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NW-15-059-05 W4M
SEPTEMBER 1972

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	FIGURE A11	
SCALE: 1:6,500		

LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/ AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.

0 50 100 m

Muriel Lake
Basin Management Society

SOLSTICE
Environmental Management

MURIEL LAKE
NW-15-059-05 W4M
AUGUST 2013

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	**FIGURE A12**	
SCALE: 1:6,500		

LEGEND

Site Boundary

Quarter Section Boundary

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NW-20-059-04 W4M
1949-1950

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:6,500

FIGURE A13

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 0125 015, ORIGINAL PHOTO SCALE: 1:40,000, DATE: 1949-1950.

0 50 100 m

LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 1197 054, ORIGINAL PHOTO SCALE: 1:31,680, DATE: 09/04/1972.

0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NW-20-059-04 W4M
SEPTEMBER 1972

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:6,500

FIGURE A14

LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/
AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.

0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NW-20-059-04 W4M
SEPTEMBER 2017

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	**FIGURE A15**	
SCALE: 1:6,500		

LEGEND

- Site Boundary
- Quarter Section Boundary

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 0125 243, ORIGINAL PHOTO SCALE: 1:40,000, DATE: 1949-1950.

0 50 100 m

Muriel Lake
Basin Management Society

SOLSTICE
Environmental Management

MURIEL LAKE
SE-01-060-05 W4M
1949-1950

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	FIGURE A16	
SCALE: 1:6,500		

LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 1197 081, ORIGINAL PHOTO SCALE: 1:31,680, DATE: 09/04/1972.

0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
SE-01-060-05 W4M
SEPTEMBER 1972

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	**FIGURE A17**	
SCALE: 1:6,500		

LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/ AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.

0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
SE-01-060-05 W4M
AUGUST 2013

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:6,500

FIGURE A18

LEGEND

- Site Boundary
- Quarter Section Boundary

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 0125 243, ORIGINAL PHOTO SCALE: 1:40,000, DATE: 1949-1950.

0 50 100 m

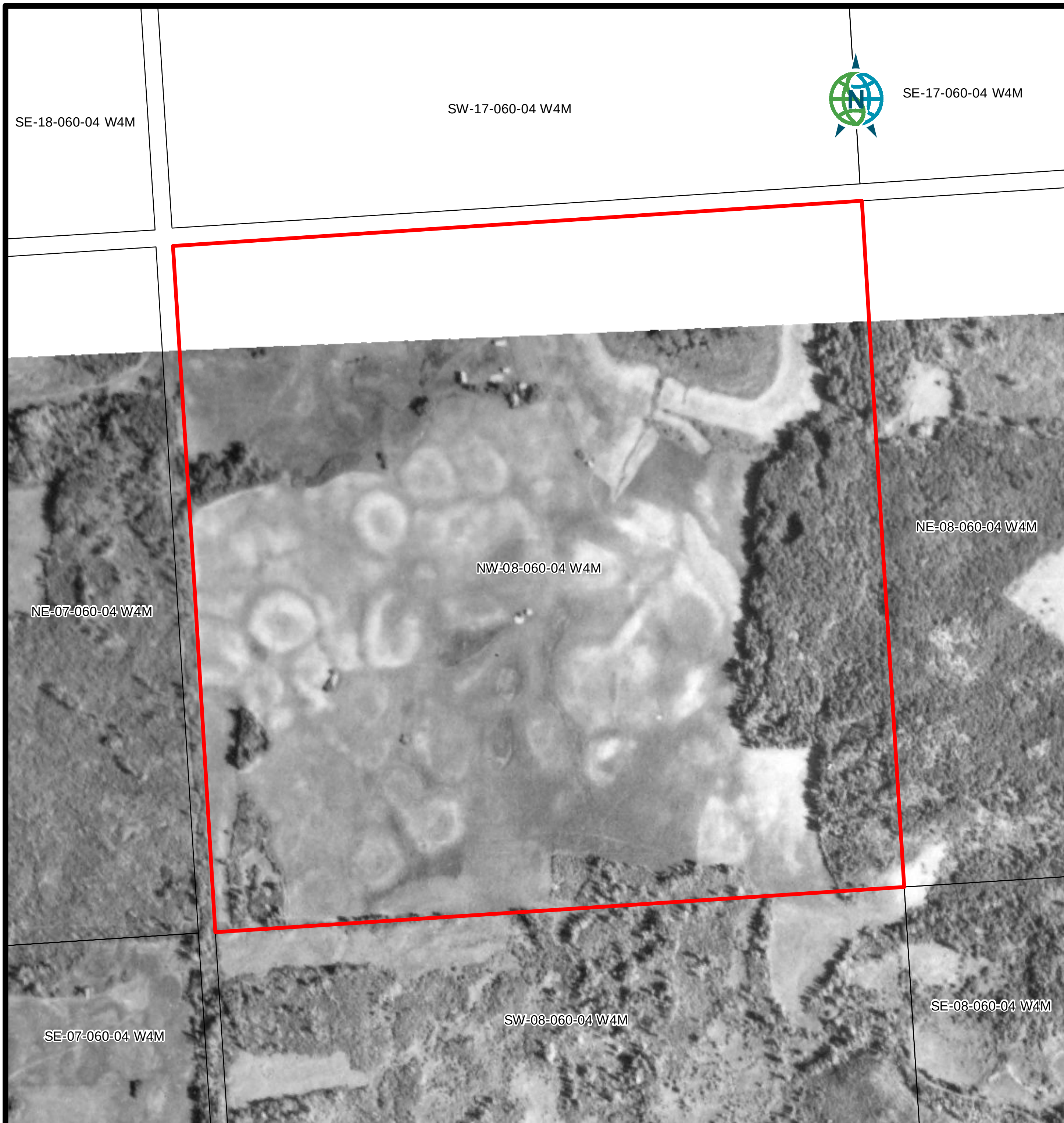
Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NW-08-060-04 W4M
1949-1950

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42		
SCALE: 1:6,500		

FIGURE A19



LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 1197 082, ORIGINAL PHOTO SCALE: 1:31,680, DATE: 09/04/1972.

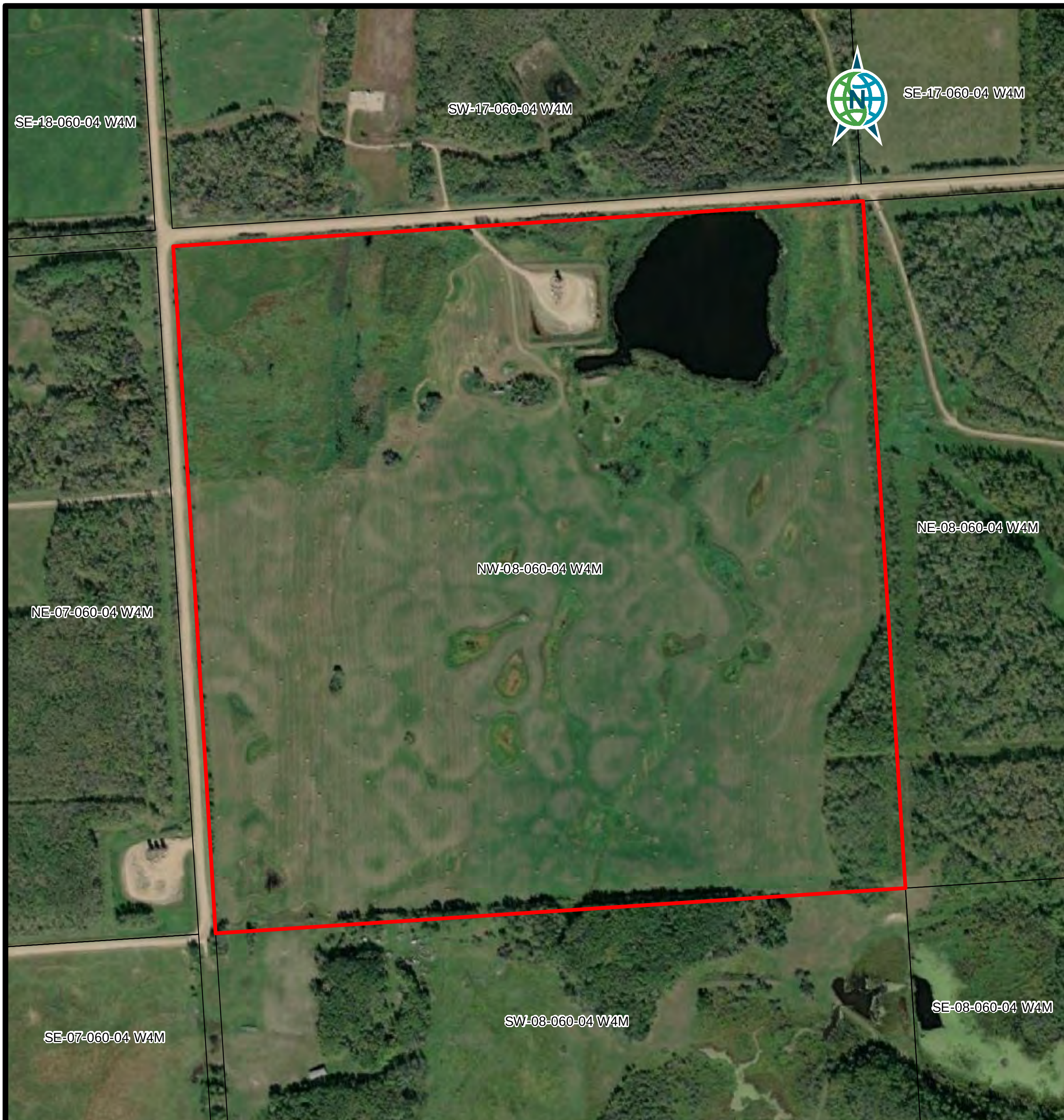
0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NW-08-060-04 W4M
SEPTEMBER 1972

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	FIGURE A20	
SCALE: 1:6,500		



LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/
AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.

0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NW-08-060-04 W4M
SEPTEMBER 2017

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	FIGURE A21	
SCALE: 1:6,500		

LEGEND

Site Boundary

Quarter Section Boundary

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NE-08-060-04 W4M
1949-1950

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:6,500

FIGURE A22

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 0125 243, ORIGINAL PHOTO SCALE: 1:40,000, DATE: 1949-1950.

0 50 100 m

LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 1197 082, ORIGINAL PHOTO SCALE: 1:31,680, DATE: 09/04/1972.

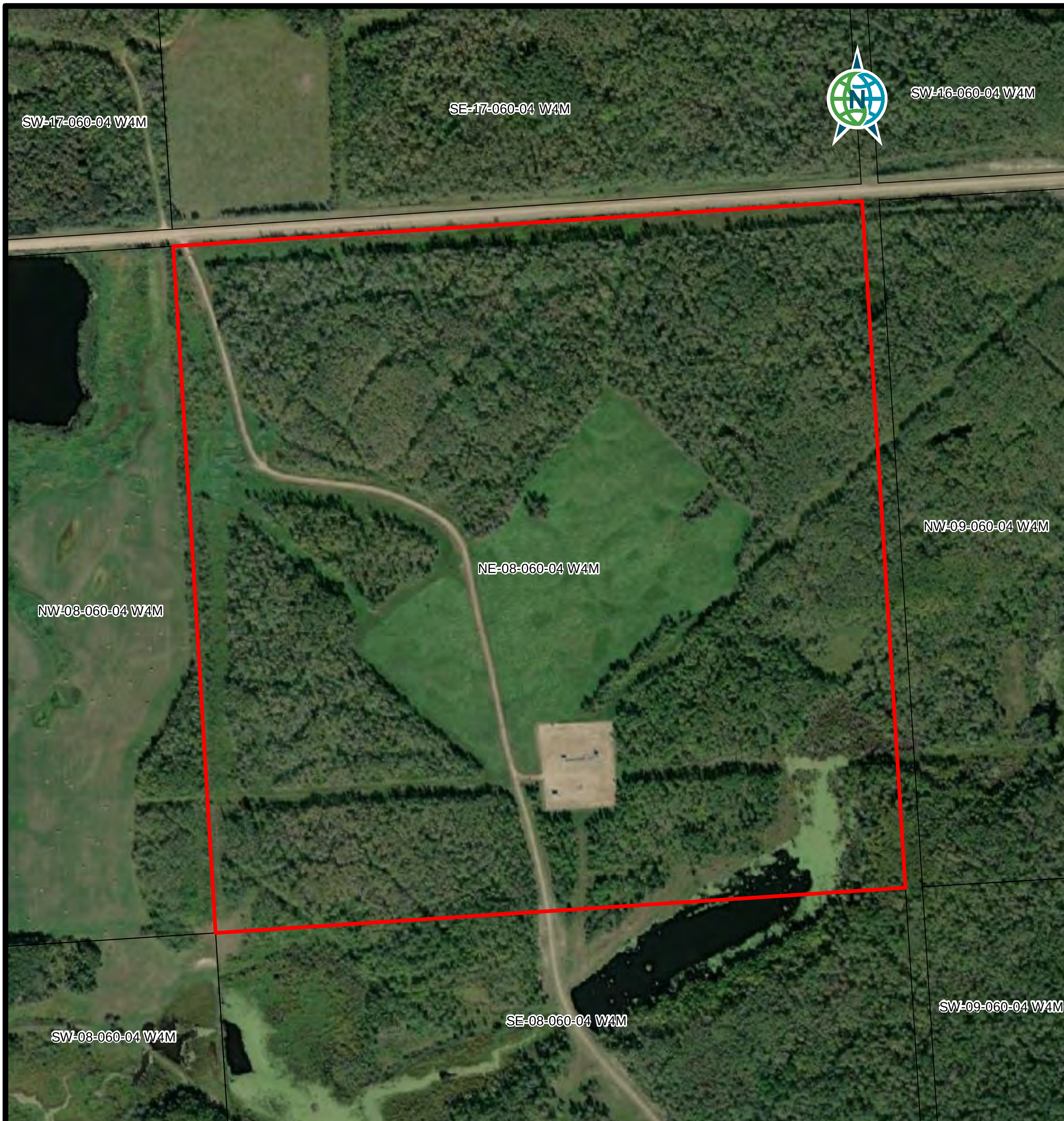
0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NE-08-060-04 W4M
SEPTEMBER 1972

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	**FIGURE A23**	
SCALE: 1:6,500		



LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/ AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.

0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
NE-08-060-04 W4M
SEPTEMBER 2017

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83

PROJECT CODE: 20-13135-42

SCALE: 1:6,500

FIGURE A24

LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 0125 243, ORIGINAL PHOTO SCALE: 1:40,000, DATE: 1949-1950.

0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
SW-08-060-04 W4M
1949-1950

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42		
SCALE: 1:6,500	FIGURE A25	

LEGEND

Site Boundary

Quarter Section Boundary

Muriel Lake
Basin Management Society

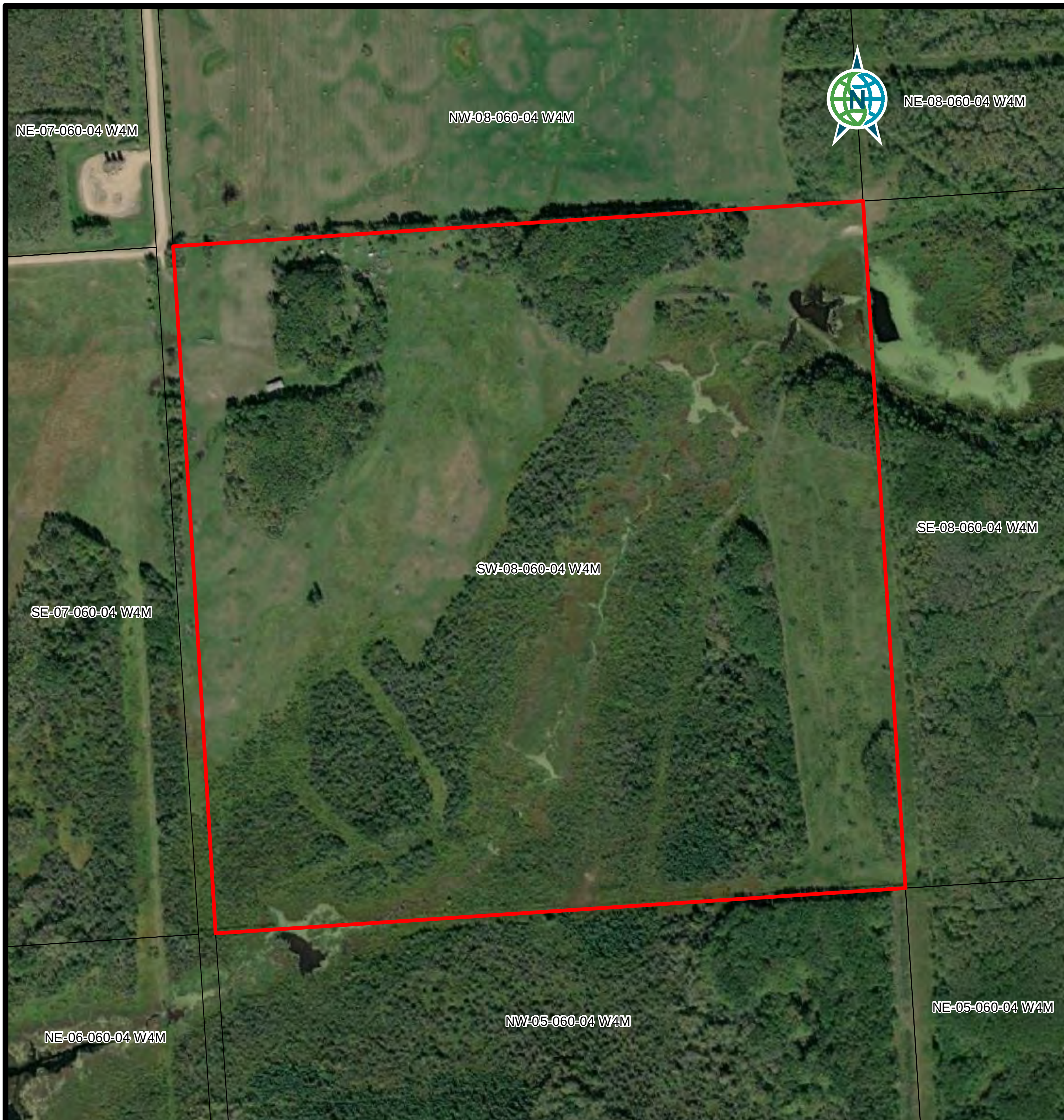
SOLSTICE
Environmental Management

MURIEL LAKE
SW-08-060-04 W4M
SEPTEMBER 1972

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42		
SCALE: 1:6,500	FIGURE A26	

0 50 100 m

SOURCE: ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 1197 082, ORIGINAL PHOTO SCALE: 1:31,680, DATE: 09/04/1972.



LEGEND

Site Boundary

Quarter Section Boundary

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
SW-08-060-04 W4M
SEPTEMBER 2017

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42		
SCALE: 1:6,500		

FIGURE A27

0 50 100 m

SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/ AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.

LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 0125 243, ORIGINAL PHOTO SCALE: 1:40,000, DATE: 1949-1950.

0 50 100 m

Muriel Lake
Basin Management Society

SOLSTICE
Environmental Management

MURIEL LAKE
SE-08-060-04 W4M
1949-1950

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42	**FIGURE A28**	
SCALE: 1:6,500		

LEGEND

Site Boundary

Quarter Section Boundary

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
SE-08-060-04 W4M
SEPTEMBER 1972

DATE:	PROJECTION:	DATUM:
SEPTEMBER 29, 2021	10TM AEP FOREST	NAD83
PROJECT CODE: 20-13135-42		
SCALE: 1:6,500		

FIGURE A29

SOURCE:
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT,
PHOTO: AS 1197 082, ORIGINAL PHOTO SCALE: 1:31,680, DATE: 09/04/1972.

0 50 100 m

LEGEND

Site Boundary

Quarter Section Boundary

SOURCE:
ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/
AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.

0 50 100 m

Muriel Lake Basin Management Society

SOLSTICE Environmental Management

MURIEL LAKE
SE-08-060-04 W4M
SEPTEMBER 2017

DATE: SEPTEMBER 29, 2021	PROJECTION: 10TM AEP FOREST	DATUM: NAD83
PROJECT CODE: 20-13135-42	FIGURE A30	
SCALE: 1:6,500		